Vol. 18 SEPTEMBER, 1945 No. 3

SURGERY

A Monthly Journal Devoted to the Art and Science of Surgery

THE JOHNS HOPKINS HOSPITAL SERIAL RECORD
NOV 27 1945

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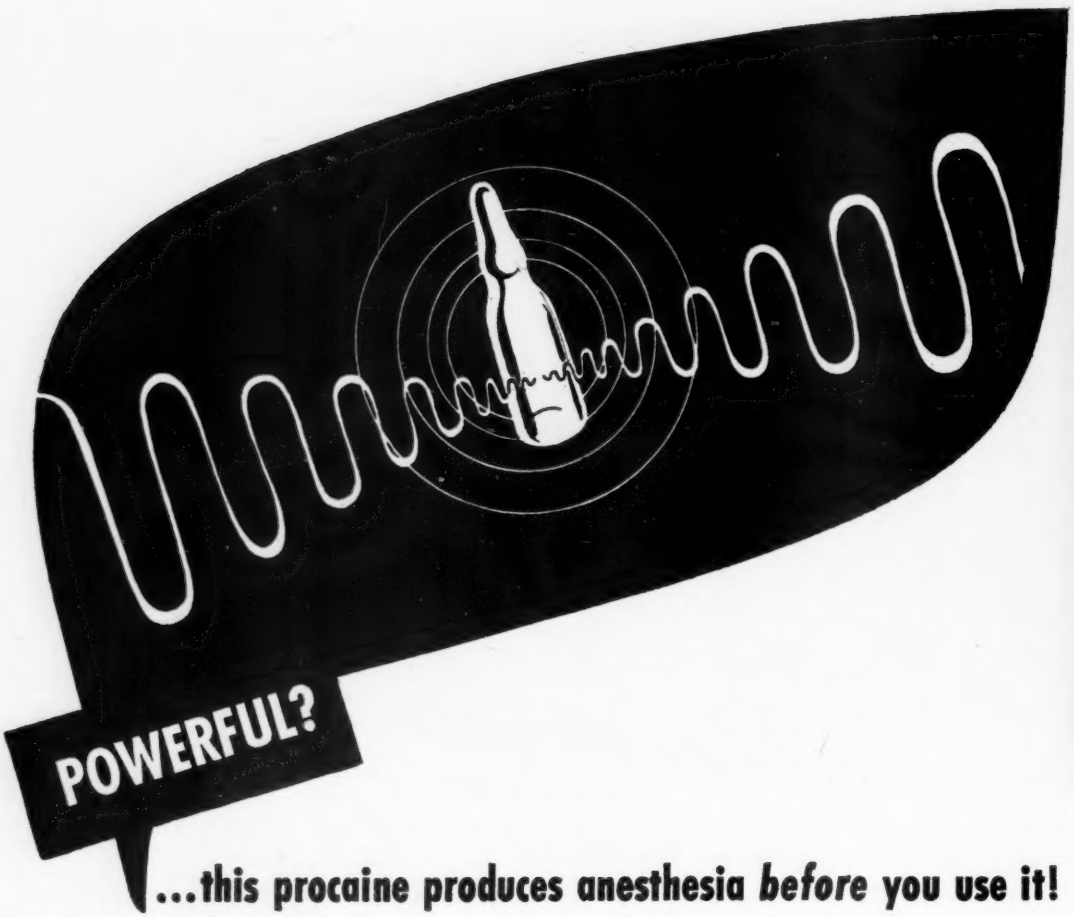

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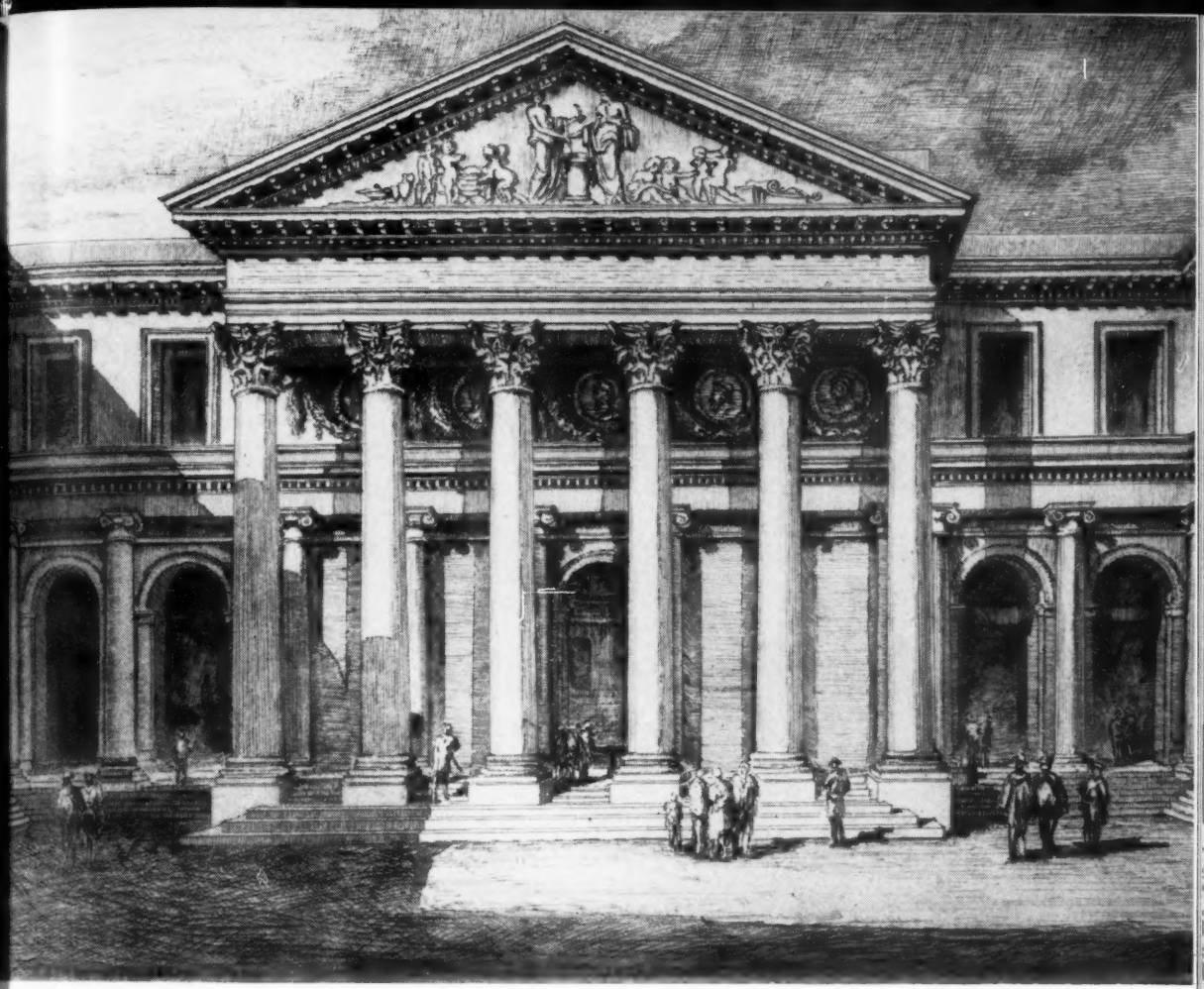

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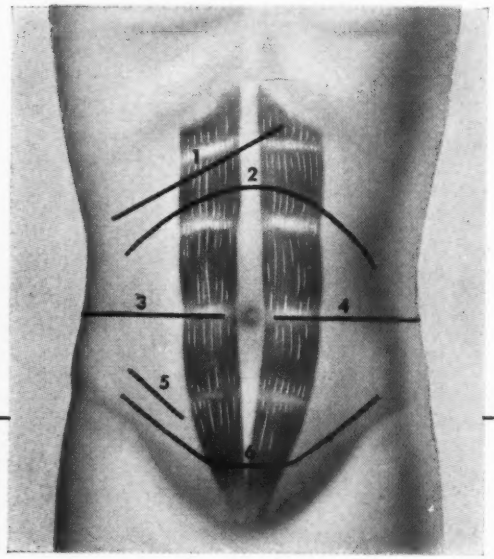

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Sutures hold most securely if the connective tissues within the wound are approximated in such a manner that the sutures must pull against the fibres within these layers. This is possible only when connective tissues are cut parallel to the direction of their fibres. In the anterior abdominal wall, this is usually best accomplished through a transverse initial skin incision.

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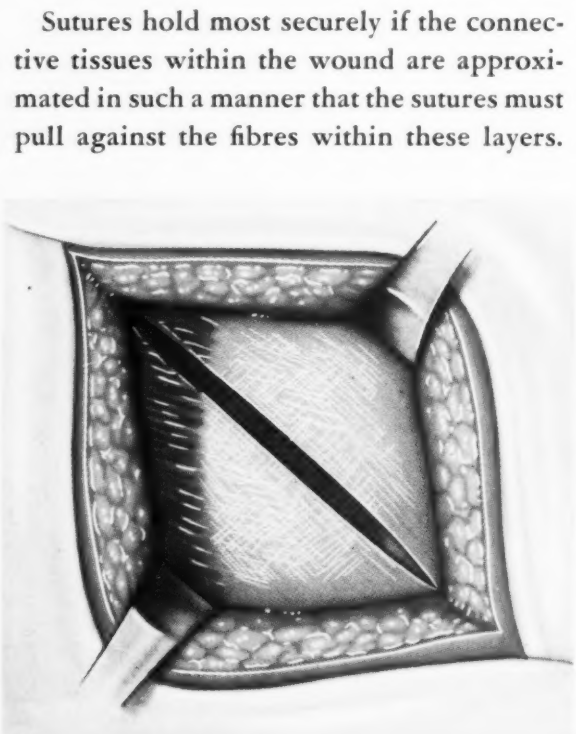
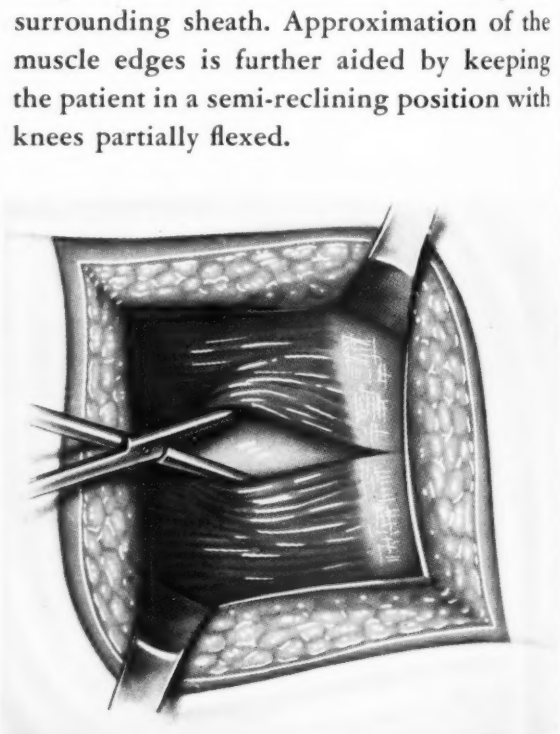




Wound Disruption

NUMBER FIVE OF A SERIES

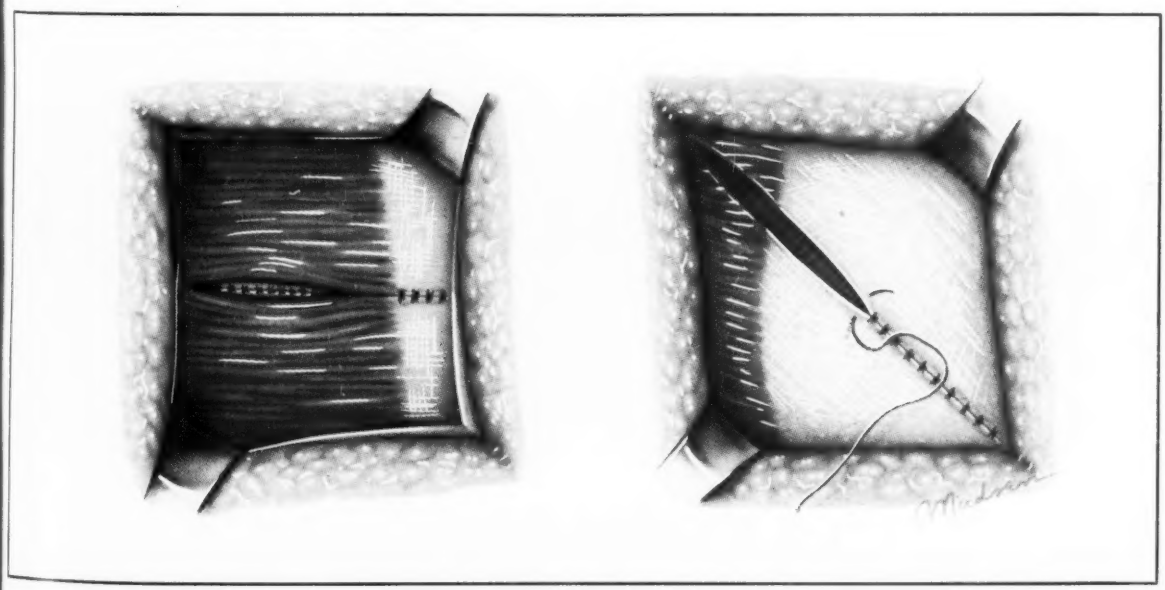
*THE McBURNEY OR GRIDIRON INCISION FOR APPENDECTOMY

The McBurney or gridiron incision employed to remove the diseased appendix is the most widely accepted yet perhaps the most frequently challenged of all incisions. Some surgeons feel that through this small incision, essential pathology may be overlooked and that the inadequate exposure it affords makes intraperitoneal surgery unnecessarily difficult. Others point out that this criticism is not justified since the incision can easily be enlarged to permit further exploration if the condition of the appendix does not explain the presenting symptoms. In addition, they cite the following advantages of the gridiron incision:

1. The retrocecal and lateral cecal appendix is more readily removed through it than through a longitudinal incision.
2. The appendiceal abscess can be drained through it without contaminating the general peritoneal cavity—a very real hazard in the treatment of the appendiceal abscess.
3. Fewer post-operative herniae are claimed for the McBurney incision than for others, and early ambulation was first practiced with this incision.

Wier obtained increased exposure with the McBurney incision by cutting the posterior and anterior sheath of the rectus muscle and retracting the muscle laterally. Since, however, experience has now demonstrated that the recti muscles can be cut without danger of subsequent deformity, the initial incision can readily be converted into a transverse incision across the entire abdomen if desired. This would seem to eliminate all criticism of the McBurney incision.

In making the McBurney incision, the skin should be cut transversely because incisions made in this direction not only spread less than the conventional slanting incision, but permit enlargement if necessary. The external oblique muscle and fascia are split in the direction of their fibres and after these are retracted the internal oblique and the muscle and fascia of the transversalis and peritoneum are cut horizontally. To enlarge the incision, the interior epigastric vessels are ligated and the rectus muscles and their sheaths are cut transversely. As with all the other transverse incisions, only the fasciae are sutured and all sutures pull against the fibres of the tissues.



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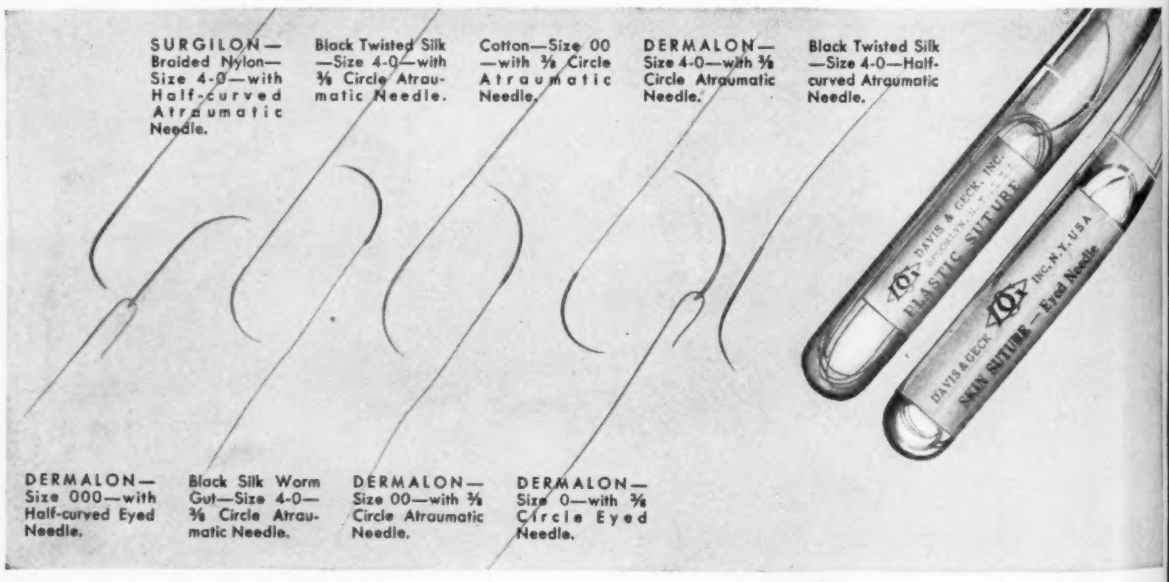
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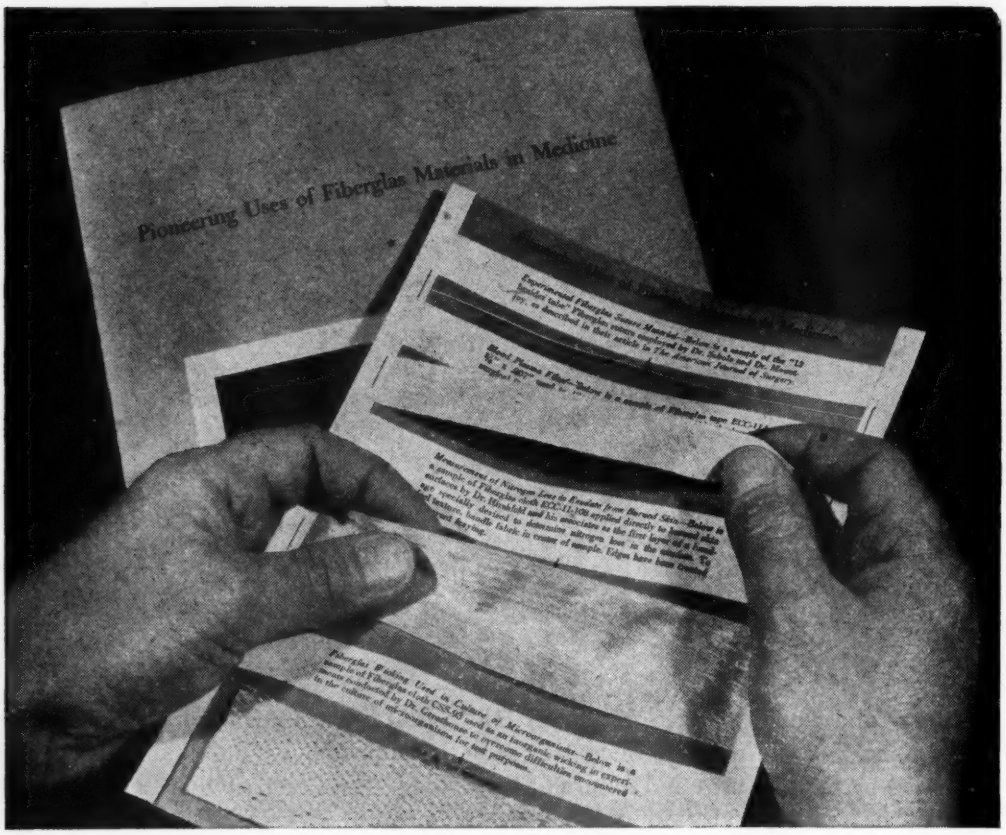

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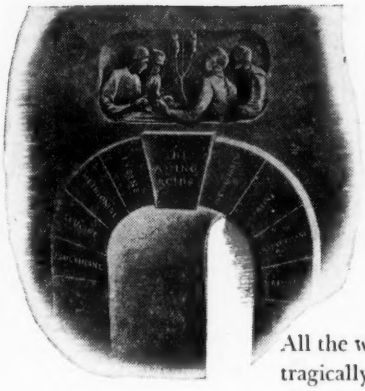

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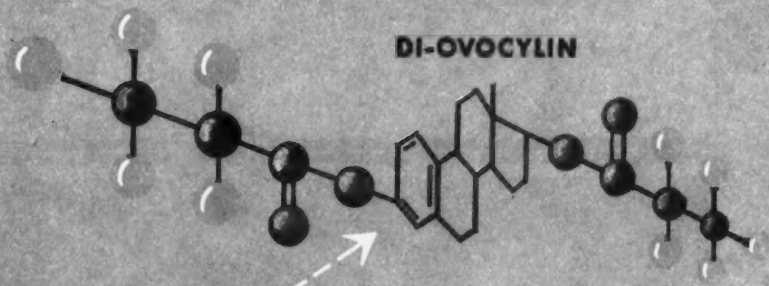

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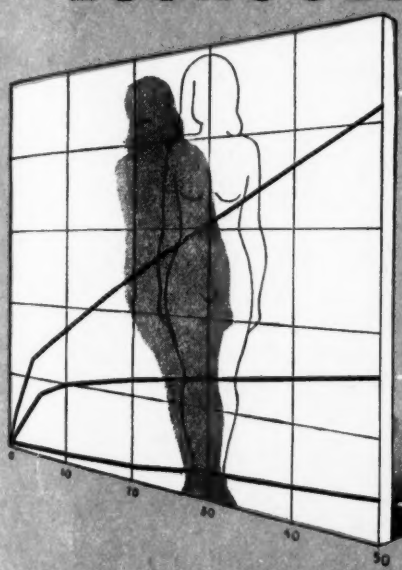

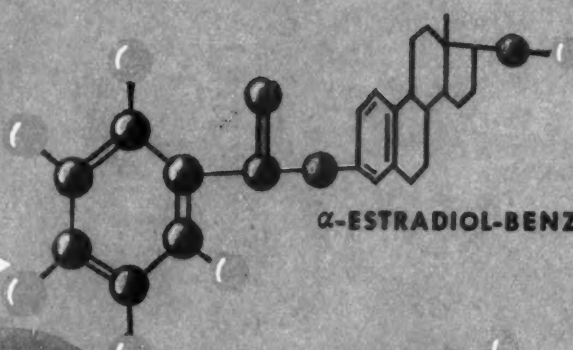

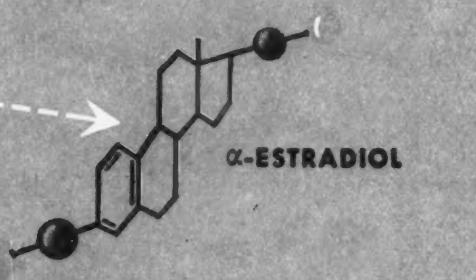

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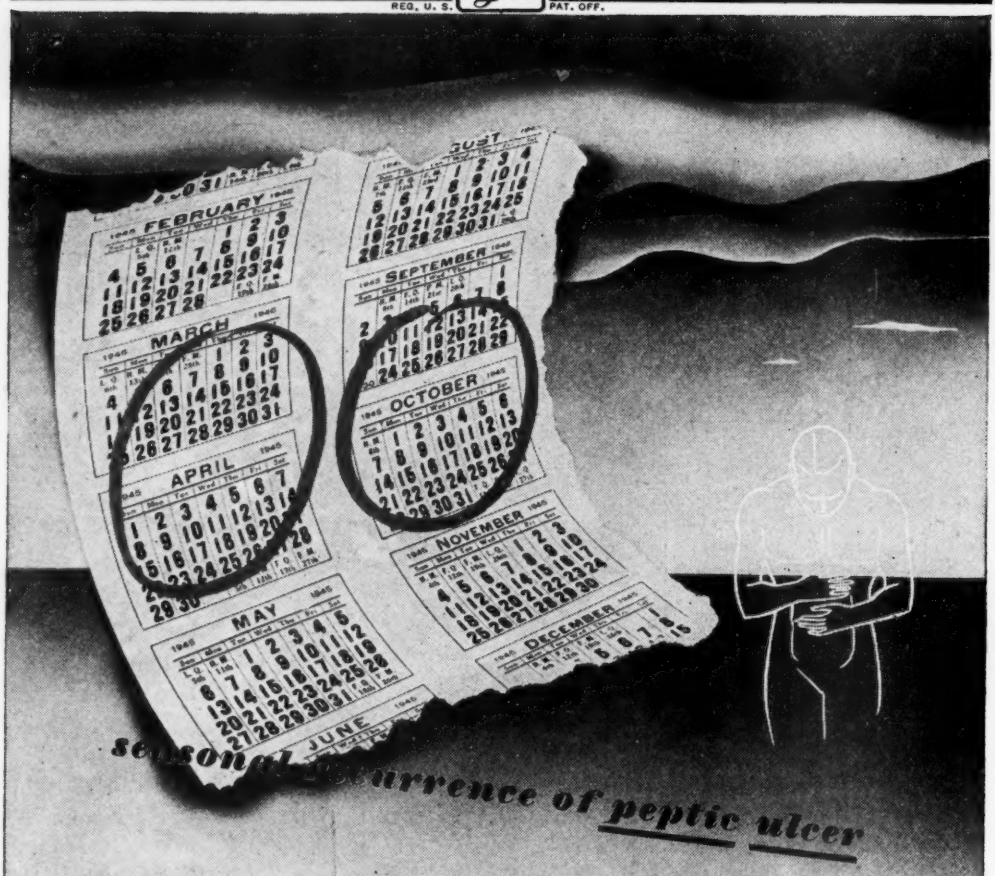

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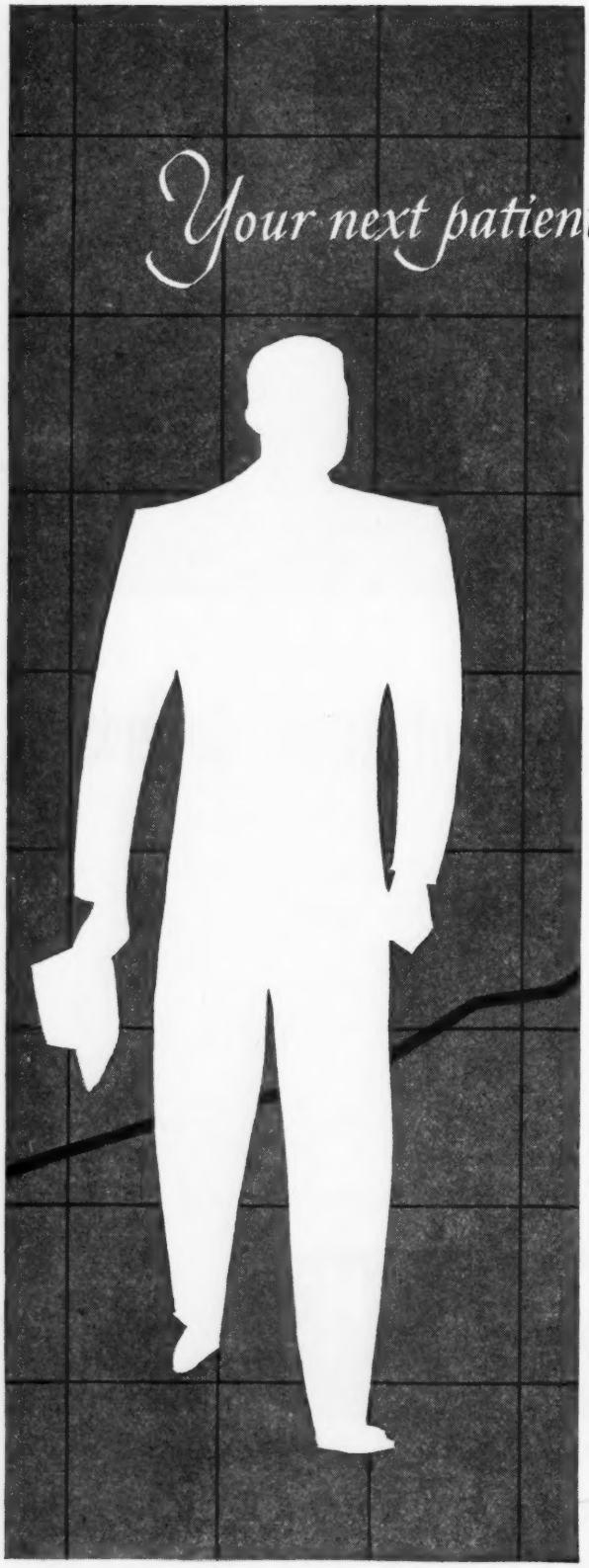

A REVIEW of the records of over 45,000 selectees by Blotner and Hyde* reveals an incidence of diabetes among young adults much greater than earlier studies have indicated. In the eighteen to twenty-five-year age group, the number of cases was found to be three to four times as high as shown in the National Health Survey. In men of twenty-five to forty-five years, diabetes occurred four to five times as often as in the previous estimate. Another striking fact—78 percent of the cases thus discovered were not aware of ever having had diabetes!

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*Blotner, H., and Hyde, R. W.: New England J. Med., 229:885, 1943.

SURGERY

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Original Communications

LATERAL CERVICAL (BRANCHIAL) CYSTS AND FISTULAS

A CLINICAL AND PATHOLOGIC STUDY*

HARRY B. NEEL, M.D.,† AND JOHN DEJ. PEMBERTON, M.D.,‡ ROCHESTER, MINN.

THE great variety of lesions which may occur, the difficulty in differential diagnosis, and the hazards of operative procedures in a field compact with important and vital anatomic structures make cervical lesions worthy of study. Interest in cervical lesions has been stimulated by the controversy concerning the origin of many of the congenital cysts and sinuses of the neck. This controversy has made the embryologic development important in the study of these lesions.

If the etiology of congenital lesions of the neck were understood completely, the terminology could be placed on a less confusing basis. In 1832, Ascherson[1] thought he recognized a close relation of the branchial apparatus to the cysts and sinuses which appear on the lateral surface of the neck anterior to the sternomastoid muscle. In 1864, Heusinger[2] introduced the term "branchial fistula." Senn,[3] in 1884, wrote that the terms previously used to designate these tumors were "branchial cysts, dermoid cysts of the sheath of the internal jugular vein, deep-seated atheromatous tumors, tumors of branchial clefts, hydrocele colli congenita, hygroma colli and atheromatous cysts of lymphatic glands." Senn considered the designation of them as "branchial cysts" as the most appropriate.

In 1912, Wenglowski[4] questioned whether these cysts and sinuses originated from the branchial apparatus. Frazer[5] objected to use of the word "branchial" because he said these abnormalities were not of branchial origin and had nothing to do with the branchiae. In order to avoid commitment to a theory of origin, many observers have begun to classify these lesions as lateral cervical cysts and sinuses. Frazer preferred to designate them as "vestigial" and there is little doubt but that his term is a most appropriate one. In this study the various terms will be used interchangeably with no implication as to etiology. It is felt that "branchial" has been used so extensively in the literature and has been so well fixed in the minds of medical men that an attempt to discontinue its use will result only in confusion.

Matas,[6] Senn,[3] Christopher,[7] Carp and Stout,[8] Hyndman and Light,[9] Bailey,[10-12] Baumgartner[13, 14] and others have made excellent contributions to

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*Abridgment of thesis submitted by Dr. Neel to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

†Fellow in Surgery, Mayo Foundation. Now on duty with the Medical Corps of the U. S. Navy.

‡Division of Surgery, Mayo Clinic.

the clinical aspects of this subject and innumerable cases have been reported in the literature. Data on a large series of cases from one source have never been reported, however, so it seemed appropriate to analyze and study the cases in which operation was performed at the Mayo Clinic, for, as Baumgartner[14] has noted, "a fundamental knowledge of the subject is not generally held."

EMBRYOLOGY OF THE STRUCTURES OF THE NECK

In the second week of intrauterine life, five depressions occur in each lateral wall of the primitive pharynx. These depressions or outward projections are known as the pharyngeal pouches and are lined by the pharyngeal entoderm. Concomitant with the outpouching of the pharyngeal entoderm, five indentations appear in the ectoderm. These indentations have been designated the "branchial or pharyngeal grooves." Each pouch is opposed by the corresponding groove so that entoderm and ectoderm are in apposition. The mesoderm is pushed aside by the encroaching ectoderm and entoderm with the result that five or six bars or arches make their appearance. In fish these arches are separated by clefts but in man only the pouches and grooves intervene. Each arch contains a basis of cartilage, a vascular arch, nerves, and muscle elements.

The first and second arches are the mandibular and hyoid arches. They grow more rapidly than their companion arches and override the latter in a telescoping process; the second arch comes in contact with the body wall behind the fifth groove and covers the second, third, and fourth grooves. The space thus formed is known as the cervical sinus. It is an enclosed pocket of ectoderm which normally disappears during the second month of intrauterine life.

In the fourth week of intrauterine life the human embryo has no neck. The cephalic prominence is bent so that the heart reaches forward almost to the first arch. The arches from above downward become shorter and the medial ends lie farther and farther apart. The result is a triangular area with the apex cephalad. This is the mesobranchial field of His.[15] From the embryonic visceral arches, their pouches and grooves, the greater part of the neck is derived.

It is well known that as the primitive ventral aorta enters the pharynx, it immediately divides into the right and left ventral aortic roots. From these roots branches (aortic arches) pass upward in the branchial arches and terminate in the dorsal aortae which run backward and unite to form the dorsal thoracic aorta. In fish these aortic arches persist, and, with their capillary network, absorb the oxygen from the water which passes through the gills.

In man, however, this condition is transitory and further alterations ensue. The first and second aortic arches disappear but the facial artery and the lingual artery mark the anterior ends of those arches, respectively. The third aortic arch remains as the first part of the internal carotid artery and the fourth on the right forms the first and second stages of the right subclavian artery. On the left side the fourth aortic arch gives origin to that part of the arch of the aorta which lies between the carotid and the entrance of the ductus arteriosus, and later becomes the ligamentum arteriosum.

From the first groove the external auditory meatus is derived, and the first pouch gives rise to the eustachian tube and tympanum. The tympanic membrane probably is derived from the cleft membrane. The first or mandibular arch grows more rapidly than the others and divides into two portions,

a superior or maxillary and an inferior or mandibular portion. The former gives rise to the upper jaw and the lateral parts of the upper lip and the cheeks; the inferior portion becomes the lower jaw, the lower lip, the region of the chin. This arch contains a rod of cartilage, known as Meckel's cartilage, which gives rise to the intracartilaginous bony structures, the sphenomandibular ligament, the malleus, and incus.

It has been noted that the remaining grooves become covered by the hyoid (second arch) operculum and participate in the formation of the cervical sinus. From the second pouch the angle of the tonsil arises. The second or hyoid arch gives rise to the styloid process, the styloid ligament, the stapes, and the lesser cornu of the hyoid bone.

The pharyngothymic duct arises from the third pharyngeal pouch while the body of the hyoid bone and the posterior part of the tongue have their origin in the third arch. The parathyroid glands are derived from the third and fourth pharyngeal pouches. The thyroid ducts, anlage of the lateral lobes of the thyroid gland, are derived from the fourth pharyngeal pouch. The thyroid cartilage is developed from the fourth arch while the cricoid and arytenoid cartilages and rings of the trachea probably represent the fifth and sixth arches.

It has been pointed out that each arch has its nerve and this nerve supplies the muscles of the arch, the pharyngeal lining, and groove recess of the arch. In fact, the embryonic origin of the muscles of the arches is identified by the nerve supply of the muscles. As the cephalic prominence rises from the thoracic wall the neck increases in length, the arches descend, and the muscular elements migrate. This migration is not always regular, however, and the greatest irregularity is found in the muscles of the second arch which pass upward into the face and scalp (occipitofrontalis muscle and muscles of expression) and downward into the neck (platysma muscle). This migration accounts for the wide distribution of the seventh nerve, the nerve of the second (hyoid) arch. The nerve of the first arch is the third division of the trigeminal nerve; that of the third arch, the glossopharyngeal nerve; that of the fourth arch, the superior laryngeal branch of the vagus; and of the fifth and sixth arches, the inferior laryngeal branch of the vagus.

ETIOLOGY

There is no general agreement concerning the etiology of lateral cervical cysts and fistulas. Although we have reviewed all the theories, space will not permit an exposition of them. It was thought by Ascherson[1] that the lesions result when the cleft boundaries fail to fuse. It was pointed out by His[15] that the partition between the pharynx and the outside groove is thin and, under abnormal circumstances, may tear and give rise to a fistula. Rabl[16] studied the second arch intensively and considered the level of the second furrow the logical place for a fistula to enter the pharynx. Carp and Stout[8] concluded that nearly all types of branchial anomalies were understandable on this basis. Wenglowski,[4] whose work has been given much acclaim, was of the opinion that lateral cervical cysts and fistulas were vestiges of the thymic duct.

MATERIAL AND METHOD OF STUDY

In the files of the Mayo Clinic, and acceptable for this study, were the case records of 319 patients who had been operated upon for lateral cervical cysts or fistulas from 1908 to October, 1938, inclusive. A few records could

not be included because the patients did not submit to operation and the diagnosis, therefore, was not confirmed. Others were discarded because of insufficient data. The surgically removed specimens were available in 287 of the cases. In the remainder of the 319 cases, the specimens had been misplaced, discarded, or had deteriorated to such a degree that they were of no value. In each of these cases the specimen had been examined and described by the surgical pathologist, however, so that complete pathologic information was known. In this study we did not include any case in which pathologic material was not available or had not been adequately described. The preauricular sinuses and cervical appendages, both of which are thought to have etiologic factors similar to those of lateral cervical cysts and fistulas, were not included.

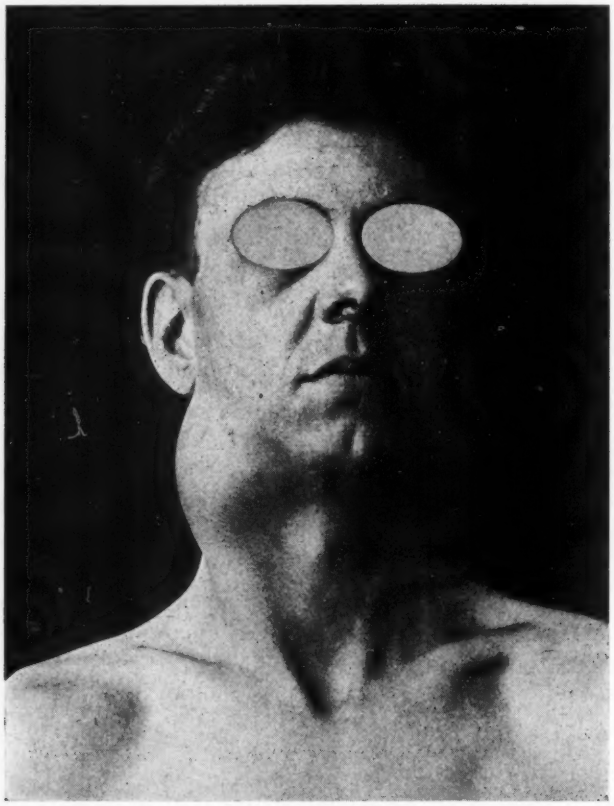

Fig. 1.—A lateral cervical cyst presenting in the most common location, just below the angle of the jaw.

In most of this report no attempt is made to segregate the cysts and the fistulas, but in our discussion of clinical findings the number of cysts and fistulas encountered in our series is listed. Not infrequently a cyst is associated with a fistula, and far too frequently a cyst is converted into a fistula by the surgeon's scalpel. It is not always possible to state with certainty that a lesion in question was primarily a fistula or a cyst.

That lateral cervical cysts and fistulas are comparatively rare is attested by the fact that only small numbers of patients with these conditions have been seen at large medical centers.

HISTORY AND SYMPTOMS

By far the most frequent symptom is a painless swelling in the neck (Fig. 1). In 259 of the 319 cases studied, the chief complaint was the presence of

a mass. Even in a part which is almost constantly exposed, as is the neck, the cyst may reach large proportions before it is observed. This fact is undoubtedly explained by the gradual increase in the size of the cyst, as occurred in 117 of the cases studied (Table I). Rapid enlargement was observed in only

TABLE I. PREDOMINANT SYMPTOMS

SYMPTOMS	CASES
Gradual enlargement of cyst	117
Symptoms preceded by or associated with upper respiratory infection	61
Draining sinus	58
Pain	53
Intermittent swelling	39
Rapid enlargement of cyst	26
Dysphagia	17
Drainage in pharynx, or peculiar taste	16
Fever	14
Husky voice	6
Pressure	6
Retraction on swallowing	6
Bulging or fullness in floor of mouth or pharynx	5

twenty-six cases. Variation in the size of the cyst is mentioned by many observers and was reported by thirty-nine of the patients in our series. This phenomenon is explainable if the cyst can empty its contents into the pharynx through a small opening. It probably is caused more frequently by the physiologic activity of the lymphatic structures contained in the wall of the cyst, however.

The association of cervical cysts with infections of the upper part of the respiratory tract is striking. Sixty-one patients in the group under consideration stated that the recognition of the presence of their lesions was preceded by, or associated with, infections of the upper part of the respiratory tract.

A draining sinus was the complaint in fifty-eight cases. At birth the external end of the fistula may be only a dimple in the skin and several years may elapse before mucoid fluid escapes, or only a drop or two of clear fluid will escape at intervals. Some of the patients gave a history of the formation of a mass in the neck, which, when pressed on, disappeared after drainage of a considerable quantity of fluid from the sinus. The majority of the fistulas are produced by the ill-advised incision of a cyst. A cyst treated by incision may continue to drain continuously until completely removed surgically, or the opening may heal only to break down and drain again. One of the patients included in this study found that the intake of food, especially liquids, caused an increase in the drainage from the fistula. Fortunately, pressure phenomena are not often present but occasionally, because of the swelling, obstructive symptoms with respiratory embarrassment may develop.

Pain is present in only a small percentage of cases of lateral cervical cysts and fistulas. Of 319 patients, only 53 had discomfort and frequently this was extremely mild. When a cyst assumes large proportions, it impinges on adjacent structures and may give rise to a sensation of pressure, drawing, or fullness and may cause dysphagia and huskiness of the voice.

A cervical cyst or fistula is occasionally said to produce symptoms of a systemic character. Inflammation is the most common complication associated with these lesions and it is certainly conceivable that an infected cyst or sinus could be the focus of infection.

The length of time patients defer seeking medical advice after the appearance of disease continues to amaze physicians. The duration of symptoms in

TABLE II. DURATION OF SYMPTOMS IN 319 CASES OF LATERAL CERVICAL CYSTS AND FISTULAS

DURATION OF SYMPTOMS (YR.)	PATIENTS	PER CENT
Less than 1	100	31
1 to 9	162	51
10 to 19	32	10
20 to 29	9	3
30 to 39	3	1
40 to 49	3	1
Not known	10	3

cases of cervical cysts and fistulas varies tremendously (Table II). In studying our 319 cases it was found that symptoms had been present for less than one year in 100 cases and from one to nine years in 162 cases. Three patients stated that they had had symptoms for more than forty years! In twenty-five cases the lesion was present at birth.

History of Trauma.—The history of a blow occasionally has been given as a factor in the production of a cyst and such a history may have medicolegal aspects. A few cases have been reported in which blood was found in the cyst. Case 1 is of some interest.

CASE 1.—A man, aged 22 years, stated that a cyst on the right side of the neck was first observed when he was 8 years old. It had gradually increased in size. Just before registration at the clinic the patient had been struck on the neck by a ball. The cyst immediately became sore and tender and a constant ache occurred. The cyst covered the anterior third of the clavicle. It was completely excised. On pathologic examination the cyst was found to be a typical branchial cyst and was filled with blood clots.

CLINICAL FEATURES

Lateral cervical cysts and fistulas appear with equal frequency in the two sexes. Of the 319 patients, 171 (53.6 per cent) were males and 148 (46.4 per cent), females. The ages varied from extreme youth to old age but 117 patients were in the third decade of life. The youngest patient was aged 4 months and the oldest was 84 years of age.

In 140 cases (44 per cent) the lesion was on the left side; in 172 (54 per cent), on the right side, and in 7 (2 per cent), on both sides. Two hundred thirty-nine of the lesions were cysts and eighty were fistulas. There were forty external fistulas, thirty-one complete fistulas, and nine internal fistulas.

In practically all cases the cysts were anterior to the sternomastoid muscle. By turning the head and placing the muscle on the stretch this relationship can be demonstrated to better advantage (Fig. 1). The muscle may be thinned out over the cyst, or, more rarely, a portion of the cyst may be present on each side of the muscle. The size of the cyst varies from that of an olive (2.5 by 1.5 cm.) to the size of a large orange (about 10 cm. in diameter) but the actual size of the cyst cannot always be detected clinically.

Fluctuation can be elicited in many cases. This sign cannot be relied on, however, for in large, tense cysts, those with thick walls, those with cheesy contents, and in deep-seated cysts, fluctuation is not easily obtained and the cyst may be mistaken for a solid tumor. Nearly all the cysts transmit light poorly. Unless there has been considerable reaction in or around the cyst wall, it is movable and not fixed to the skin or underlying structures. It presents a regular outline and the skin over it is smooth.

Possibly the close relationship existing between cyst or fistula and the vagus nerve accounts for the occasional production of a spasmodic cough when a probe is inserted.

TABLE III. ANATOMIC POSITION OF CYSTS AND EXTERNAL OPENING OF FISTULAS

SITE OF CYSTS AND EXTERNAL OPENING OF FISTULAS	CASES	PER CENT
In upper part of neck, at angle of jaw	234	74
In middle part of neck	26	8
In lower part of neck	4	1
Above sternoclavicular joint	41	13
Not stated	14	4
Total	319	100

The external opening of a branchial fistula is practically always in that part of the neck bounded by the midline medially, the sternomastoid muscle laterally, the level of the hyoid bone superiorly, and the suprasternal notch inferiorly (Table III). Usually the opening is along the anterior border of the sternomastoid muscle; the external opening of fistulas which have been present since birth is found most frequently just above the sternoclavicular articulation. Not infrequently swellings develop around the external openings.

It is generally agreed that the internal opening, when present, is in the supratonsillar fossa, although one writer[17] recently has reported finding the opening in the tonsil. In only a small percentage of the cases, however, can the internal opening be demonstrated.

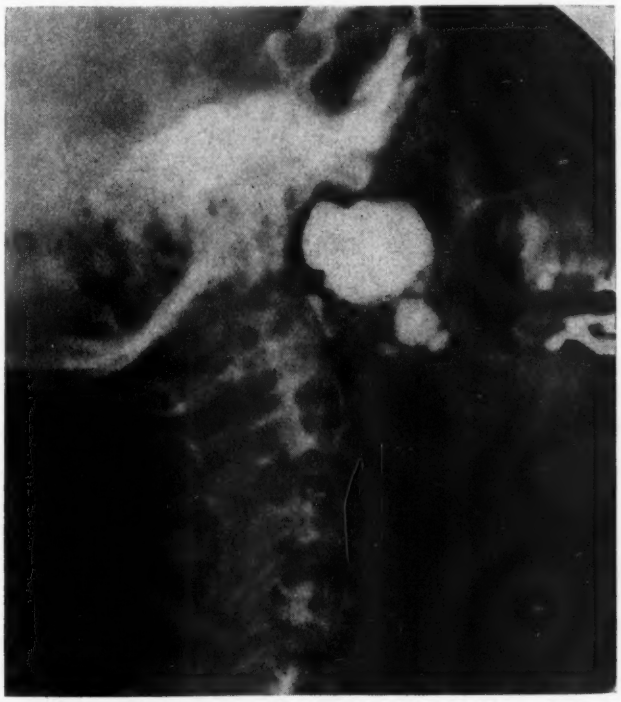

Fig. 2.—A lateral cervical cyst following the injection of lipiodal. This procedure is advocated by some clinicians as a means of distinguishing these cysts from tuberculous abscesses.

It is said that the rising of the external fistulous opening with deglutition indicates a complete fistula. According to Semken,[18] complete fistulas are present in one-third of the reported cases. Commonly the fistulous tract is palpable as a firm cord. It is possible to demonstrate the course and extent of the fistula by injecting the tract with a radiopaque substance and making a roentgenogram (Fig. 2). One hundred twenty-six patients had had previous operations (Table IV).

TABLE IV. TREATMENT AND OPERATIVE PROCEDURES PREVIOUSLY EMPLOYED

PROCEDURE	CASES	PER CENT
Incision and drainage of cyst (from 1 to 50 procedures per case)	75	24
Tonsillectomy	35	11
Roentgen rays, radium, or ultraviolet light	31	10
Attempted excision	25	8
Aspirations	14	4
Dental extractions	7	2
Iodine injection, arsphenamine, leeches (1 each)	3	1
Total cases in which previous operations had been performed for cysts and fistulas	126	40

DIFFERENTIAL DIAGNOSIS

In many instances the correct diagnosis of lateral cervical cyst and fistula must be made by the surgical pathologist. By thorough examination and by careful utilization of all the information at his command, the clinician can distinguish branchial cysts and fistulas in a high percentage of cases from numerous other lesions which appear in the neck. The correct diagnosis was made clinically in 181 of the 319 cases encountered at the Mayo Clinic. In other instances the diagnosis was suggested but other possibilities were given preference.

Tuberculous Lymph Nodes.—Branchial cysts and fistulas are most frequently confused with cervical tuberculous lymph nodes. Carp and Stout[8] stated that the close resemblance of the contents of the cysts to cold abscesses caused the incorrect diagnosis in one-half the cases. In addition to frequently having a similar appearance, the contents of the two are also sterile. Bailey[10, 11] stated that tubercle bacilli are found in only 10 per cent of tuberculous glands. This fact, together with Bailey's finding of a branchial cyst which was also tuberculous, renders the search for, and finding of, tubercle bacilli of little value, and inconclusive. In many instances enlarged lymph nodes are attached to the wall of the branchial cyst but usually the mass formed by tuberculous glands is more irregular and the skin may be adherent. The absence of enlarged lymph nodes elsewhere and the absence of other evidences of tuberculosis should be considered as evidence in favor of the diagnosis of branchial cyst.

Bailey,[10] Wangensteen,[19] Greene and Greene[20] and others have stated that the most accurate method of identifying a branchial cyst is by aspiration and examination of the fluid in the cyst. The presence of cholesterin crystals in the fluid is positive evidence of a cyst. In only one instance did Bailey[10] fail to find cholesterin crystals. In that case some substance had previously been injected into the cyst which made the contents unsuitable for examination. Wangensteen[19] said that the high lipoid content of the fluid from a branchial cyst frequently imparts a shimmer or yellowish sheen to it when it is placed in a basin. Tuberculous pus does not have these characteristics.

Tumors of the Carotid Body.—Branchial cysts are far more common than tumors of the carotid body, which are rare. It is noted that tumors of the carotid body move laterally but not vertically and that pulsation usually is transmitted. Their position is similar to that usually assumed by branchial cysts. It is important to distinguish between these two lesions before the patient is anesthetized because the operative procedure for removal of the tumor of the carotid body is of great magnitude and the prognosis is grave.

Cystic Hygroma.—The lesion of cystic hygroma is first noticed in infancy. It is usually diffuse, loculated, and translucent, and most commonly is situated

in the lower half of the neck. A branchial cyst, however, is nearly always well circumscribed, unilocular, and opaque, and is situated in the upper part of the neck more frequently than in the lower part.

Suppurative Cervical Lymphadenitis.—Acute inflammation of a branchial cyst or fistula may be difficult to distinguish from suppurative cervical lymphadenitis. The history of swelling or of drainage from a sinus preceding the inflammation may give the clue to a correct diagnosis.

Dermoid Cysts.—Dermoid cysts are said to be more superficial tumors than branchial cysts and their location is not constant. Apparently they are also rare.

Lipomas.—The fatty tumors, lipomas, are frequently lobulated, but may simulate branchial cysts. They yield no fluid on aspiration, however.

Neurofibromas.—Neurofibromas may be confused with branchial cysts. Their firm, solid consistency and their limited mobility owing to fixation to the deeper structures of the neck, however, are important features in differential diagnosis.

Hemangiomas and Lymphangiomas.—Deep-seated venous and lymphatic angiomas are occasionally mistaken for branchial cysts. When pressure is made on these tumors their contents are evacuated.

Chronic Retropharyngeal Abscess.—It may sometimes be difficult to distinguish between the swelling caused by chronic retropharyngeal abscess and branchial cyst. Coakley[21] noted the possibility of confusing the two and a case was encountered at the clinic in which the condition was treated at first as an abscess by drainage but because of the mucous character of the drainage the lesion was later removed and proved to be a cyst.

FAMILIAL TENDENCY

For many years it has been noted that branchial fistulas may occur in several members of the same family. In twenty-one of 100 collected cases, Fisher[22] found an hereditary influence, and in three generations of the same family Ascherson[1] found eight persons affected with branchial fistulas. Cases in which a strong familial tendency was present have also been reported by Cates,[23] Vaughan,[24] Tilley,[25] Hyndman and Light,[9] Carp and Stout,[8] and others. A woman seen at the clinic had bilateral cervical fistulas. Her father, paternal grandfather, brother, and a cousin on her father's side all had bilateral cervical fistulas. In addition, another brother had a branchial appendage.

CLASSIFICATION

Various classifications have been suggested for lateral cysts and fistulas. Possibly one of the oldest, as well as one of the most useful, is that of Bland Sutton.[26] He classified these lesions as follows: (1) The complete fistula, which is the prototype, has an external opening and an opening in the pharynx; (2) the external fistula has an external opening in the skin but ends internally as a cul-de-sac; (3) the internal fistula has an opening in the pharynx but the fistula ends externally as a cul-de-sac; this type is rarely recognized and is probably the rarest; Heusinger[2] thought some pharyngeal diverticula were of this nature; (4) the cyst has a closed canal both internally and externally but an unobliterated segment remains in the neck.

Bailey has divided lateral cervical cysts into four types, according to their relationship to the surrounding structures, as follows:

The cysts of type 1 are fairly superficial, are at the anterior border of the sternomastoid muscle and beneath the cervical fascia. The cysts of type 2 lie on the great vessels. The wall of the cyst may be adherent to the jugular vein. This is said to be the type most commonly encountered. In this type, and also in type 1, the spinal accessory nerve is in a constant relation posteriorly. The cysts of type 3 extend to the lateral wall of the pharynx. A large cyst may pass through the bifurcation of the carotid artery. It may extend up as far as the lateral mass of the atlas and even to the base of the skull. The cysts of type 4 are columnar epithelium-lined cysts near the pharynx. They probably produce no symptoms.

The contents of the cysts and the lining epithelium form the basis for some classifications. Hyndman and Light[9] were of the opinion that an adequate and simple classification is: (1) branchial cleft epidermoid cysts and (2) branchial cleft mucous cysts.

PATHOLOGY

Gross Pathology.—The size of lateral cervical cysts varies from less than 1 cm. to more than 10 cm. in diameter. Of the cysts in which size was recorded, 122 had a diameter greater than 5 cm. and the diameter of some of these was more than 10 cm. In eight the diameter was from 1 to 2 cm., in thirty from 2 to 3 cm., in fifty-one from 3 to 4 cm., and in forty-nine from 4 to 5 cm.

A cyst is usually longer than it is wide, and is shaped like an egg or lemon (Fig. 3*a*). Some, however, are nearly spherical. There frequently is a suggestion of lobulation. The entire cyst is surrounded by a loose connective tissue through which course veins and small arteries. In eighty-eight of the specimens examined lymph nodes were attached to the walls of the cysts.

The thickness of the cyst wall varies tremendously. Carp and Stout[8] found this variation to be from 1 mm. to 1 cm. Some of the walls are as thin as tissue paper and collapse into a small heap as soon as they are punctured, allowing the contents of the cyst to escape. The walls may be nearly 1 cm. thick, however, and when the contents of such a cyst are evacuated the specimen maintains its shape. The thin walls are opaque and glistening while the thicker walls are darker.

The inside of a cyst wall usually presents a far more interesting picture (Fig. 3*b*). The thinnest walls may be perfectly smooth, but when those a little thicker are held in a proper light very small projections may be seen. The epithelial lining of some of the cysts is pinkish and may be easily stripped from the underlying tissue. This lining may be smooth or wrinkled, simulating skin which has been immersed in water. On nearly every lining membrane there are wartlike projections or papillomas. These vary in size and in number; they may be barely visible, but are occasionally from 5 to 6 mm. in diameter. They may be few in number or numerous enough to cover the entire cyst wall (Fig. 4*a*).

Thin septa may traverse the cyst wall and divide it into irregular compartments (Fig. 4*b*). Frequently these septa converge to the same place on the cyst wall. The septa have the appearance of fibrous cords or contractures, and give the cyst wall a trabeculated appearance. Papillomas my be present also, but rarely on the septa.

The gross and microscopic appearances of a fistula are shown in Figs. 5 and 6 *a* and *b*.

Microscopic Pathology.—Typically, the microscopic study of a lateral cervical cyst or fistula reveals a stratified squamous epithelium which lies on a

lymphoid base, the latter in turn being surrounded by a layer of loose connective tissue. In different specimens the layers vary in thickness and in other respects (Figs. 7 *a* and *b*, 8 *a* and *b*, and 9). It is probably advisable to discuss each component separately.

In 263 of the 287 specimens of cysts and fistulas examined histologically at the clinic the lining was of squamous-cell epithelium. In eighteen cases it was columnar and in six cases both columnar and squamous-cell epithelium

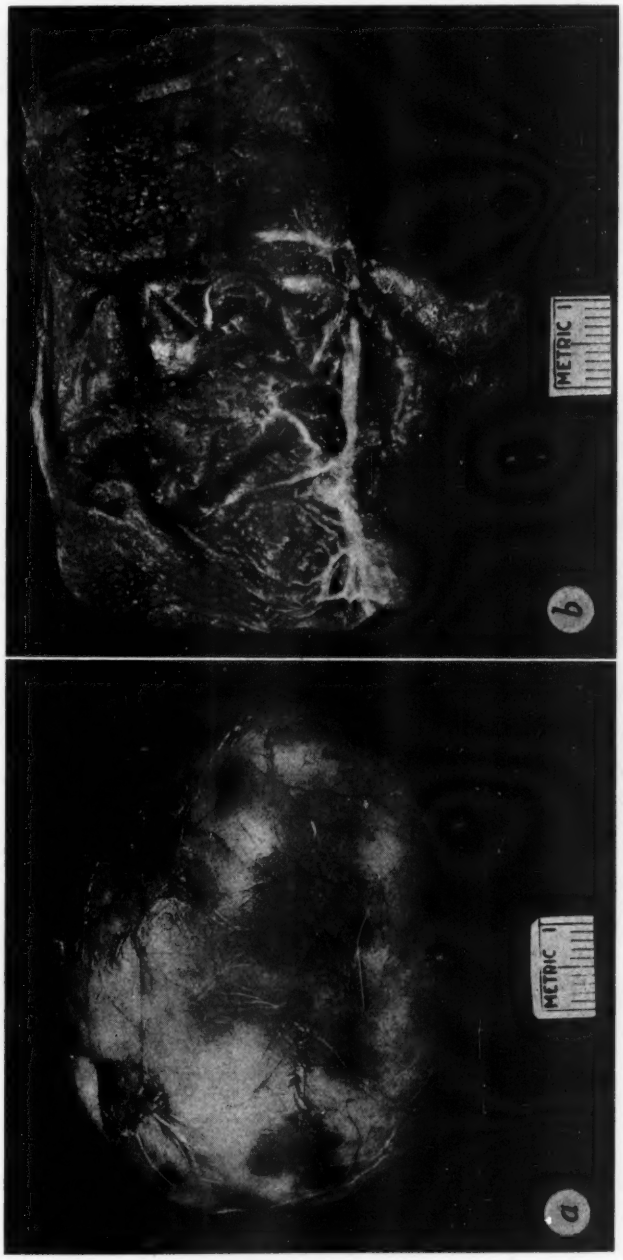

Fig. 3.—*a*, External appearance of a moderately large cyst; the loose connective tissue, the blood vessels, and the lobulations are shown; *b*, interior of a cyst showing the wrinkling of the epithelium and the wartlike projections.

were found (Fig. 9). Bailey[12] has said that a fistula is lined by columnar ciliated epithelium unless inflammation has been present. This observation is not substantiated by the findings in our series. In some fistulas the epithelium is of columnar type, but in the majority it is of the squamous-cell type.

In addition to finding the structure of branchial cysts constant, Gilman[27] also found that the number of cell layers in the lining of squamous-cell epi-

thelium varies at different areas. This finding coincides with the observations made in our study, but when the epithelium was found to be thick at one area, it was usually only a trifle less thick at the thinnest area. In other words, there was a tendency to maintain approximately the same number of cell layers throughout. In 176 instances the epithelium was found to be of average or moderate thickness; in seventeen it was definitely thick, and in ninety-four thin.

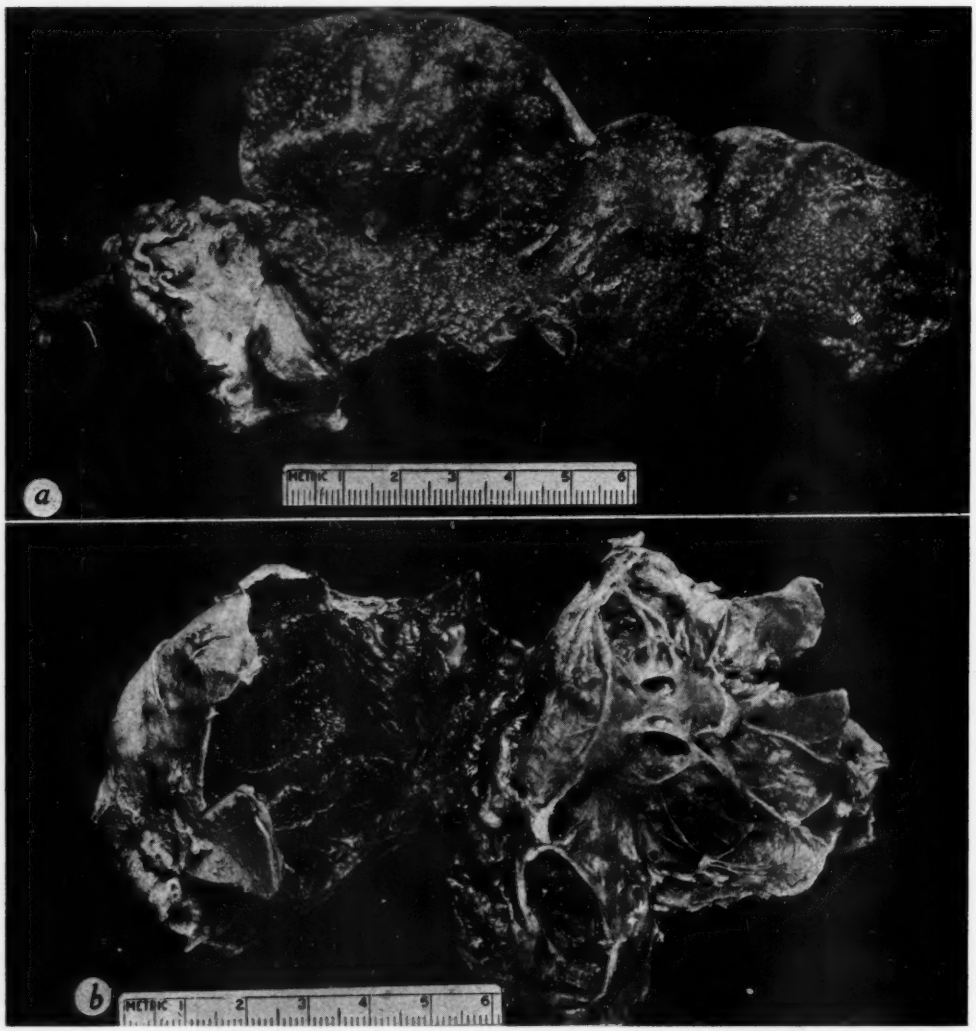

Fig. 4.—The interior of a large cyst; *a*, the wall is thick; the entire inner surface is covered by confluent wartlike projections of the squamous epithelium; *b*, the cordlike bands which divide the cyst into trabeculations.

It is true that in the majority of instances the epithelial layer rests on a base of lymphoid tissue (Fig. 7*b*), as was observed in 185 of the specimens examined. In ninety-one specimens the epithelium rested on connective tissue (Fig. 8*b*), however, and in eleven cases it rested on both lymphoid and connective tissue. Germinal follicles were present in the lymphoid band in 137 of the 287 specimens examined (Fig. 8*a*). Gaston[28] said that follicles are such a constant finding that they are of diagnostic importance, a statement not supported by our study. In 119 of our specimens the lymphoid tissue was scant, in 138 moderate, and in 30 thick.

The supporting layer of connective tissue also varies greatly in its width, as seen in the cross section. In fifty specimens in our series it was thick, in 139 average or moderate, and in ninety-eight thin. It sometimes is penetrated deeply by lymphoid tissue which seems detached from the main lymphoid band. Blood vessels are numerous and around many of them are accumulations of round cells. In the event of acute inflammation this supporting layer of connective tissue becomes engorged with leucocytes. Serous glands are occasionally found in this layer and muscle fibers are occasionally present. In 276 specimens studied in our series chronic inflammation was present in the connective tissue layer, in three inflammation was acute, and in ten no inflammation was found.

Fig. 5.—Bilateral complete cervical fistulas removed through a single collar incision.

Contents.—The epithelium lining the cyst or fistula retains its capacity to form the products of epithelial metabolism. These products are discharged into the cyst or fistula and compose the contents or the drainage. Hyndman and Light[9] found a thick, transparent, mucoid, sticky fluid in the cysts and

fistulas lined by columnar epithelium and an opaque, watery, and milky or cheeselike substance in those lined by squamous epithelium. The fluid in some of the cysts is thick and amber; it may be clear or turbid and is rich in cholesterol.

Branchial Carcinoma.—Branchial carcinoma, fortunately, is rare. Crile and Kearns[29] stated, in 1935, that fewer than 100 cases had been reported and Carp and Stout found only 4 of 1,538 carcinomas which were thought to have a branchial origin. There has been considerable dispute concerning the origin of malignant lesions found in this region.

It was hoped that in the examination of 319 pathologic specimens of branchial cysts and sinuses, evidence could be obtained to throw some light on this unsettled question. There was no suggestion of carcinoma in any specimen,

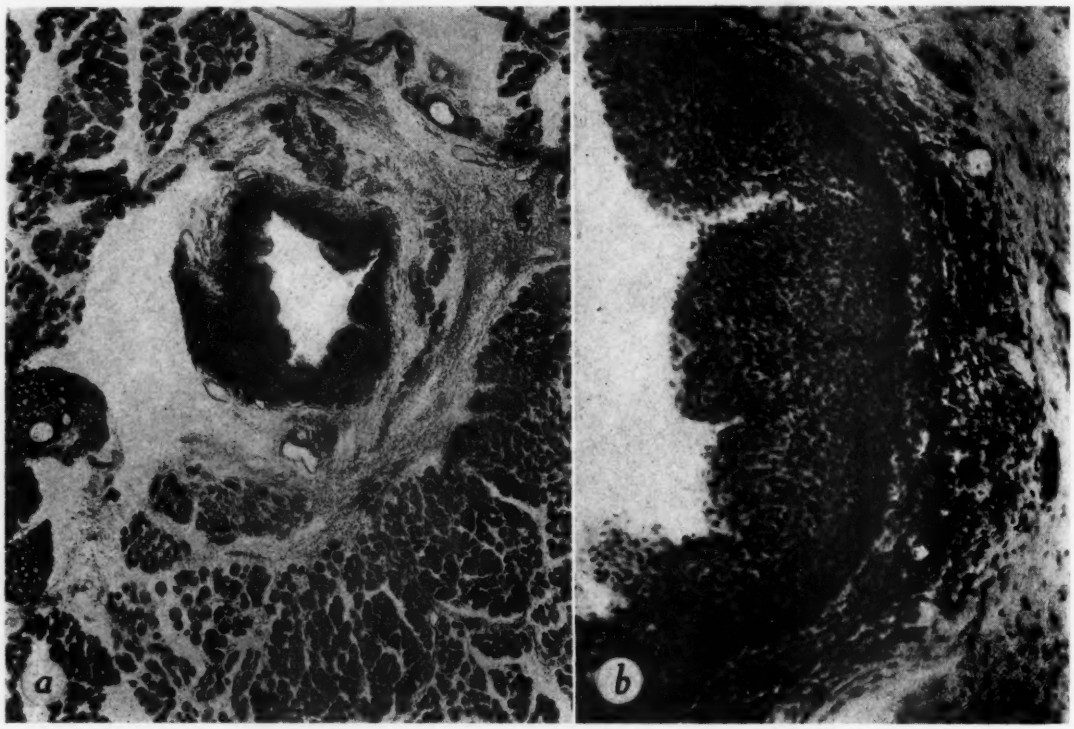

Fig. 6.—Cross section of one of fistulas shown in Fig. 5; *a*, there is an abundance of muscle tissue and a gland at the periphery (×22); *b*, thick lining of stratified squamous epithelium (×115).

however. Broders[30] was of the opinion that cervical, squamous-cell epitheliomas are secondary to an obscure and undiscovered primary lesion.

TREATMENT

In the presence of acute suppuration, excision is out of the question. Conservative measures, such as the local application of heat, rest, the forcing of fluids, and administration of sedatives, are indicated. If the inflammatory reaction does not subside, incision and drainage may be necessary when the infection has localized, as was done in three cases in our series. Excision of the sinus and cyst can be undertaken at a later date.

The injection treatment of lateral cervical fistulas has been favored at times but, as a rule, has been spurned. Beck[31] advocated the injection treatment for infants who were less than 12 to 18 months of age. The skin must be carefully protected with tincture of benzoin or with tannic acid solution.

Surgical.—Surgeons in general are of the opinion that total extirpation of the cyst or fistula offers the only sure cure. Excision of a cyst may not be difficult but the complete excision of a fistula in which inflammatory reactions have occurred may be attended by unusual technical difficulties.

In order to identify the tract with greater ease, some surgeons inject methylene blue into the fistula. Baumgartner[14] has suggested that methylene blue be used and then washed out with saline solution. Enough dye is left on the wall to stain it but there is not enough to soil and stain the operative field. Christopher[32] injected molten paraffin and dissected the fistula with ease.

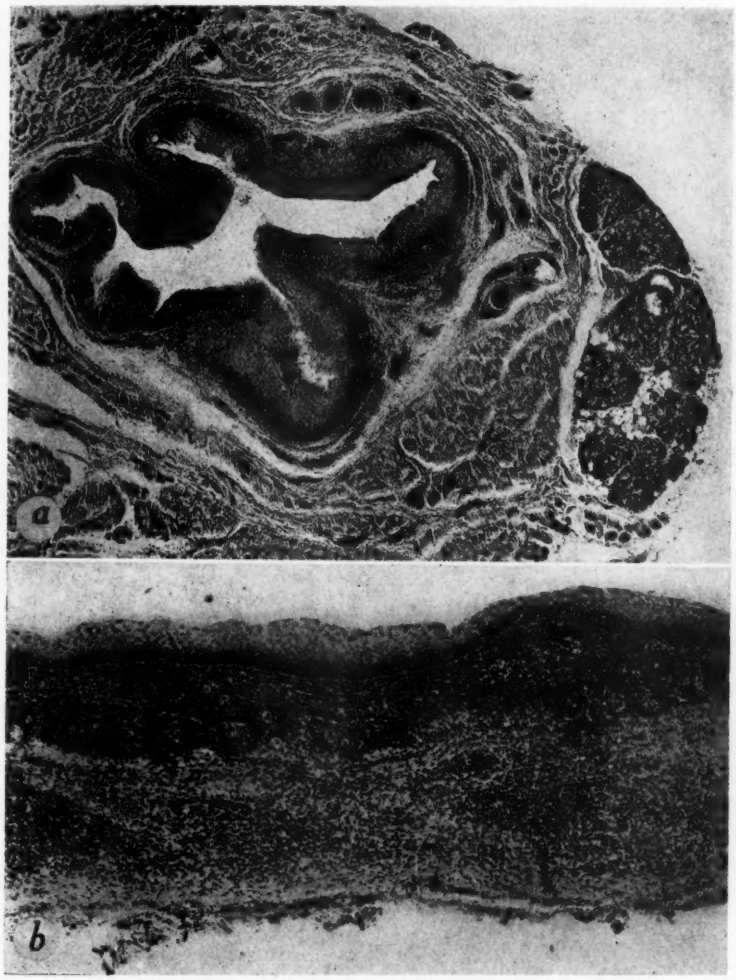

Fig. 7.—*a*, Cross section of a cervical fistula with a gland at the periphery (×30); *b*, typical and most frequently observed microscopic picture (×55) of lateral cervical cyst with squamous epithelial lining, a band of lymphoid tissue, and connective tissue.

Because of better cosmetic results we prefer a single transverse incision through, or parallel to, one of the natural creases of the skin of the neck. If the incision is made near the middle of the cyst or fistulous tract and both upper and lower flaps consisting of skin and platysma muscles are well reflected from the underlying fascia, adequate exposure can be easily obtained for the excision of the cyst or fistulous tract.

In dissecting the fistulous tract it is usually found to lie under the platysma muscle and the outer layer of the middle cervical fascia, on the sternohyoid and sternothyroid muscles. It passes upward parallel to the sternomastoid muscle and in close relationship with the carotid sheath and the jugular vein.

At the level of the hyoid bone it turns inward and proceeds toward the pharynx. Apparently, some fistulas pass over the carotid sheath and some pass between the external and internal carotid arteries, for there is disagreement on this point. The fistula then crosses over the hypoglossal nerve, passes under the posterior belly of the digastric muscle, over the glossopharyngeal nerve, under the styloglossus muscle, and to the pharynx near the tonsil.

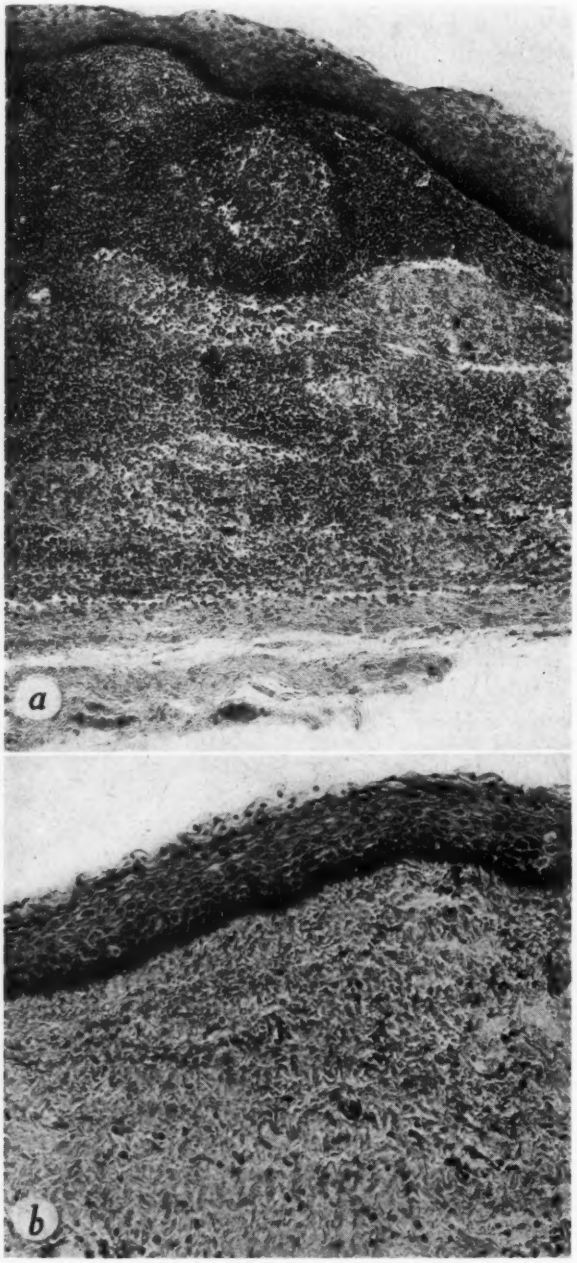

Fig. 8.—Cyst wall; *a*, which shows a secondary follicle in the lymphoid tissue (×90); *b*, in which the stratified squamous epithelium lies directly on the connective tissue.

Several methods of dealing with the internal portion of the fistulous tract have been described. In the procedure described by von Hacker[33] the medial end of the fistula is cut and cauterized. Through this stump a probe is cautiously passed into the pharynx. The end of the probe is made fast to the

cut end of the fistula and by gentle traction on the probe through the mouth the fistula is inverted into the pharyngeal cavity, where it is ligated and cut off short. If the fistula cannot be dissected to the pharynx a technique described by Koenig[34] may be employed. By bringing the distal end of the fistula into the buccal cavity in front of the tonsil the secretions are caused to drain into the mouth instead of externally. Both the von Hacker and the Koenig procedures are beautifully illustrated in Christopher's article.

Fig. 9.—Cyst wall which shows both columnar and stratified squamous epithelium (×80).

It has not been found necessary to invert the stump of the fistula into the pharynx in all cases, just as it is not essential to invert the stump of the appendix in all cases. If the fistula is dissected to the pharyngeal wall, ligated close to the wall, cut and carbolized or cauterized, a good result can be anticipated. This method was employed in thirty-four cases at the clinic (Table V). Ladd and Gross[35] did not find it necessary to turn the stump into the pharynx.

It must be emphasized that it is absolutely necessary to remove the entire tract. If a long medial portion is allowed to remain, a complete fistula will have been converted into an internal fistula and the latter may be as annoying as the former.

Removal of a cyst usually offers far less difficulty than excision of a fistula. In the superficial type an incision is made over the cyst in a natural crease in the skin and the cyst enucleated. Those cysts which are in close

TABLE V. OPERATIVE PROCEDURES EMPLOYED AT CLINIC

OPERATIVE PROCEDURE	CASES
Excision	283
Dissection to pharynx and opening demonstrated surgically	34
Drainage instituted	3
Curettage	1

relation to the great vessels may be adherent (Fig. 10). Bailey occasionally found it necessary to divide the sternomastoid muscle and isolate the spinal accessory nerve. This nerve should always be identified. If the cyst is large and exposure cannot be readily obtained, the cyst may be aspirated. Bailey[10] then placed gauze and forceps over the puncture wound and made gentle traction on the cyst wall. Bevan[36] stated that if he ever were unable to complete the dissection he thought he would prefer to take a segment of the jugular vein rather than leave part of the wall of the cyst and cauterize. As previously mentioned, in order to effect a cure, it is essential to remove all of the secreting epithelium.

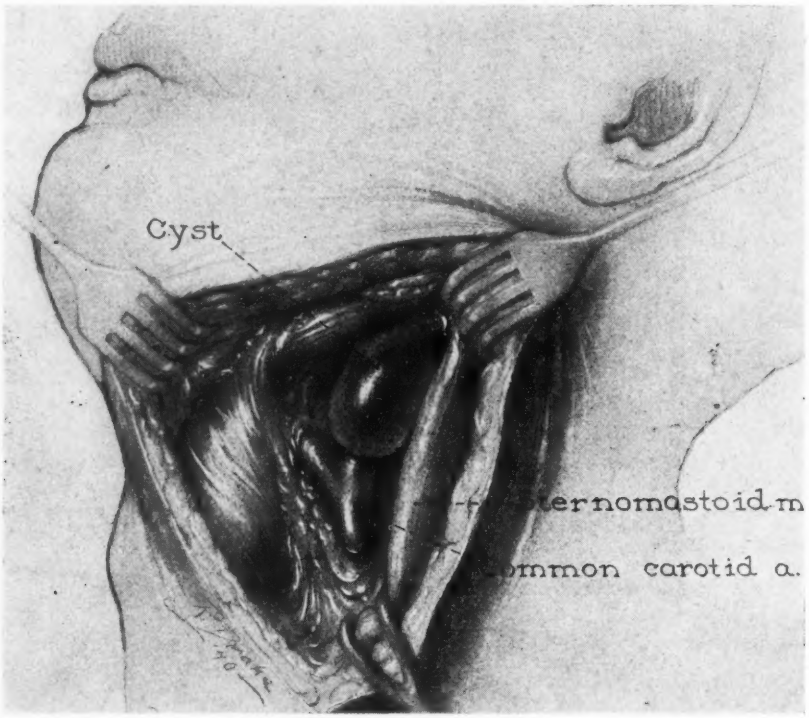

Fig. 10.—Location most commonly assumed by lateral cervical cysts and the relations to the great vessels.

RESULTS OF TREATMENT

Two deaths followed 321 operations performed at the clinic on 319 patients in a period of about thirty years, an operative mortality of 0.63 per cent. Gaston[28] reported one death in twenty-nine cases, an operative mortality of 3.4 per cent. One fatality in our series was that of a child, aged 1 year, who had not been well since birth. An attempt to remove a large cervical cyst had previously been made. The cyst protruded into the pharynx and interfered with respiration. In spite of the child's poor condition, extirpation of the cyst was considered advisable. Operation was performed Jan. 3, 1912. The cyst weighed 15 Gm. and measured 4 by 2.5 by 2.5 cm. On the fifth postoperative day the patient died of bronchopneumonia.

The second patient who died was a man, aged 49 years, who had syphilis. He had a large cyst which had enlarged rapidly and in the few weeks before admission it had caused dyspnea on exertion. The cyst occupied the submaxillary and submental regions. The floor of the mouth bulged and the

larynx could not be seen. Feb. 25, 1924, the cyst was excised. In twenty-four hours the patient had difficulty in breathing and his voice became throaty. The wound was explored but no evidence of fresh hemorrhage was found. The patient died on the operating table. Death was attributed to edema of the larynx and tissues of the neck.

The final result of operation for lateral cervical cysts and fistulas is gratifying. If we assume that the 147 patients who have not been heard from are well, 309 patients have obtained a satisfactory result. The incidence of recurrence is small.

Late postoperative complications which were caused by injuries to nerves occurred in twelve cases. Apparently, the glossopharyngeal nerve is the nerve most frequently injured since three patients complained of atrophy and deviation of the tongue. Two patients had atrophy of the muscles of the shoulder girdle and two presented Horner's syndrome.

SUMMARY

Congenital cysts and fistulas which appear on the lateral aspects of the neck are referred to as branchial, vestigial, and lateral cervical. There is no unanimity of opinion as to the etiology of these lesions. The work and theory of Wenglowski,[4] however, have greatly influenced thought on this subject.

Several members of the same family, and of one or more generations, may be afflicted. Other congenital lesions also are encountered occasionally in cases of lateral cervical cysts and fistulas.

A study was made of 319 cases in which operation was performed for lateral cervical cysts or fistulas at the Mayo Clinic. Specimens for pathologic study or data on pathologic findings were available in all cases. Detailed microscopic studies of specimens were made in 287 cases. Painless swelling was the most frequent symptom. In sixty-one cases the lesions were preceded by, or associated with, infections of the upper respiratory tract. Symptoms not infrequently appeared following tonsillectomy.

In our series patients of both sexes were affected equally. The ages of the patients varied from 4 months to 84 years. The greatest number of patients (37 per cent) were in the third decade. The two sides of the neck were involved approximately equally. The lesions were bilateral in 2 per cent of the cases.

In the great majority of cases the lateral cervical cyst was located in the upper cervical region near the angle of the jaw.

In the complete and internal fistulas the internal opening usually is in the supratonsillar fossa. It is difficult to demonstrate clinically.

Lateral cervical cysts and fistulas must be distinguished from other lesions, especially tuberculous lymph nodes.

These lesions have a distinct pathology and microscopic examination is essential. The diagnosis of branchial carcinoma is probably erroneous. The lesion designated as "branchial carcinoma" is probably secondary to a healed or undiscovered primary lesion in the nasopharynx.

Conservative treatment is indicated in the presence of acute inflammation. Complete excision of the cyst or fistulas is the treatment of choice in the great majority of cases. In experienced hands the operative mortality is low.

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THE USE OF SKIN FLAPS IN THE REPAIR OF SCARRED OR ULCERATIVE DEFECTS OVER BONE AND TENDONS

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DURING the past fifteen years a series of ninety-seven patients has been operated upon with the objective of correcting chronic ulcerative lesions or deep adherent scars by means of skin flaps. In most instances these lesions have been located upon the extremities, but there also have been a few located on the head and body. In all these individuals it was deemed that skin grafts would not give adequate or proper coverage or skin grafts had been tried with ultimate failure, either because they did not "take" or had broken down later.

When a chronic ulcer is immediately over bone or heavy tendon or is surrounded by deep heavy scar, the resultant central ischemia may be such that a subcutaneous tissue provision is necessary to ensure a viable skin covering. When bone or a large tendon is uncovered, or nearly uncovered, and trauma has to be withstood, the addition of both skin and subcutaneous tissue may be obligatory. A skin flap can obtain most of its nourishment circumferentially. Occasionally in civilian life and often in warfare one will encounter a wound which has torn out skin and subcutaneous tissue, exposed tendons or nerves, severed tendons and nerves, or has resulted in loss of bone. In the first instance a thicker coverage than a skin graft may be the better coverage, in the second instance an immediate skin and subcutaneous tissue coverage may be obligatory if one is to preserve tendon or nerve function, and in the latter case skin and subcutaneous tissue are necessary both for coverage and for allowance of further operative procedures when such are contemplated.

One of our main reasons for presenting this group of defects, corrected by means of skin flaps, is to emphasize that often a skin flap can be transplanted with safety and the resultant aseptic denuded base from which the flap was removed covered by a skin graft at the first operation. This makes the procedure one which takes from between two and three weeks to execute, in contradistinction to one in which a series of delayed or tubed flaps are used which takes a matter of a number of weeks or even months. (Ghormley and Lipscomb,[1] four to seven operations, average ninety days' hospitalization.)

METHODS OF SKIN AND SUBCUTANEOUS TISSUE TRANSFER

Before going further with the discussion it might be well to summarize very briefly the various methods of skin flap transfer. Skin flaps may be transferred by the direct or delayed methods, or by means of a direct or intermediate carrier.

Direct Transfer.—In direct transfer the skin flap is elevated from its bed and transferred to its permanent situation at the first operation. This may be done by rotating the skin flap (Hindoo,[2] 5000 B.C.), by using a member such as the arm for transfer to a more distant location (Tagliacozzi,[3] 1597); by sliding the skin flap (French method) and by bringing the member to be covered to the skin flap, as the hand to an abdominal flap or one leg to the other. Direct transfer may be done when the blood supply is sufficient to allow the skin flap to remain viable.

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Delayed Transfer.—The delayed methods which tend to enhance the nutrition of the flap include: (1) raising of the skin flap and simply suturing it back in its bed with or without leaving a bridge pedicle to be cut later (Tagliacozzi,[3] 1597 and Blair,[4] 1921), (2) placing some such material as a skin graft beneath the skin flap with either unipedicling or bipedicling of the flap (Morgan,[5] of London), (3) tubing of the flap (Filatoff,[6] 1917 and Gillies[7] in 1920), (4) the use of an intermediate carrier such as raising a flap from the abdomen and attaching it to the wrist with the ultimate objective of using the arm for distant transfer (Sebileau,[8] "regional justiposition," 1926), or (5) finally jumping a skin flap end over end. (Roux,[9] 1854.)

Delayed Transfer Without Tubulization.—When practicing delayed transfer without tubulization of a skin and subcutaneous flap (Blair), the flap is outlined, raised from its bed, and immediately replaced and resutured back in its original position. As a rule, about ten days later the flap is transferred to the site to be repaired. Thus, the flap is transferred as soon as the blood supply to the pedicle has had sufficient time to increase, because of dilatation or possible increase or realignment of the blood and lymph vessels within the pedicle. The disadvantage of the method is the matter of time and the increase in the number of operations. When the blood supply is sufficient there is no necessity for using the procedure. On the other hand, the method may have four advantages. First, by its use, a longer, more narrow, and thinner flap may be obtained than if immediate transfer is made, and second, the flap may be completely outlined in piecemeal fashion, with an interval of a week or two between advancement of the incision of the smaller or the distal pedicle. Third, if the blood supply is still questionable, an interval of time can be allowed for re-establishment of the circulation, after which the flap may be raised from its bed a second time. Fourth, if, after all these methods for establishing an adequate blood supply, the blood supply of the flap still appears to be insufficient, one may leave it in its bed and save the embarrassment of losing the flap.

The Tubed Pedicle Skin Flap or Satchel Handle Flap.—The method (Filatoff, Gillies) consists of making two parallel incisions, after which the skin and all or part of the subcutaneous tissue is raised. The defect is then closed with sutures beneath the flap, or if this is impossible, a skin graft may be used to cover the denuded area. It is possible, but not desirable because of infection and contraction, to allow the bed to remain unclosed and to heal by granulation. The parallel edges of the raised flaps are sutured together so that the flap is thrown in the form of a tube or cylinder with the surface of the skin outward. By this method a greater blood supply is developed in each pedicle. This method has the advantage that an untubed flap, continuous with the distal end of the tubed pedicle, can be raised two weeks or more after the original flap is tubed. If there is any question concerning the blood supply of the distal prolongation, one may outline it, separate it, and suture it in situ one or two weeks previous to transfer to the recipient bed. If one prefers, the tube can be lengthened subsequently, so that the flap will reach a greater distance. Also, one may interrupt the incisions on one side or even on both sides, in order that a tube of almost any length can be raised and transferred later (de River,[10] 1926).

General Indications for the Coverage of Deep Defects.—When one is attempting to select the optimum method for coverage of a scarred ulcerated or deep defect one has to balance the general utility of a skin graft against that of a skin flap. Each has certain advantages. A skin graft can be placed, as a rule,

in one operation in contradistinction to a skin flap which will take at least two, and often more, operative procedures. A skin graft has about normal thickness while a skin flap is often rather thick in appearance. When there is sufficient subcutaneous tissue, a thick skin graft will stand the trauma fairly well even on the bottom of the foot. It gets a nerve supply quicker than a skin flap. The slowness with which a skin flap develops a nerve supply (nearly one year) may be quite a detriment when it is applied over such an area as the heel because of the liability of the development of a trophic ulcer if it is not protected while the nerve supply is appearing. Such lesions as large varicose ulcers often, after wide excision of the scar followed by skin grafting, give a very good result. To use a skin flap for such large lesions is almost out of the question. When sufficient subcutaneous tissue is present and one is aiming solely at surface coverage, a skin graft is preferable to a skin flap.

In general, a skin flap may have the advantages of a fairly high resistance to infection, some thickness for the purpose of filling a defect, lengthening slightly an amputated extremity, and covering with a subcutaneous tissue a thumb or finger reconstructed by means of a bone graft. By means of a skin flap subcutaneous tissue may be supplied to cover exposed tendons, nerves, and bones, to cover certain bases with deficient blood supply such as irradiation ulcers and sloughs, to facilitate the future repair of nerves or tendons, or to allow contemplated operative procedures on tendons, nerves, or bones. The skin is soft and pliable and the color is normal for the area from which it is removed. For the building of organs requiring thickness, for building a part requiring two soft pliable epithelial surfaces and some thickness such as the nose, the cheek, and the lip, and as a direcmt covering for bone or cartilage, the pedicle skin flap has little competition.

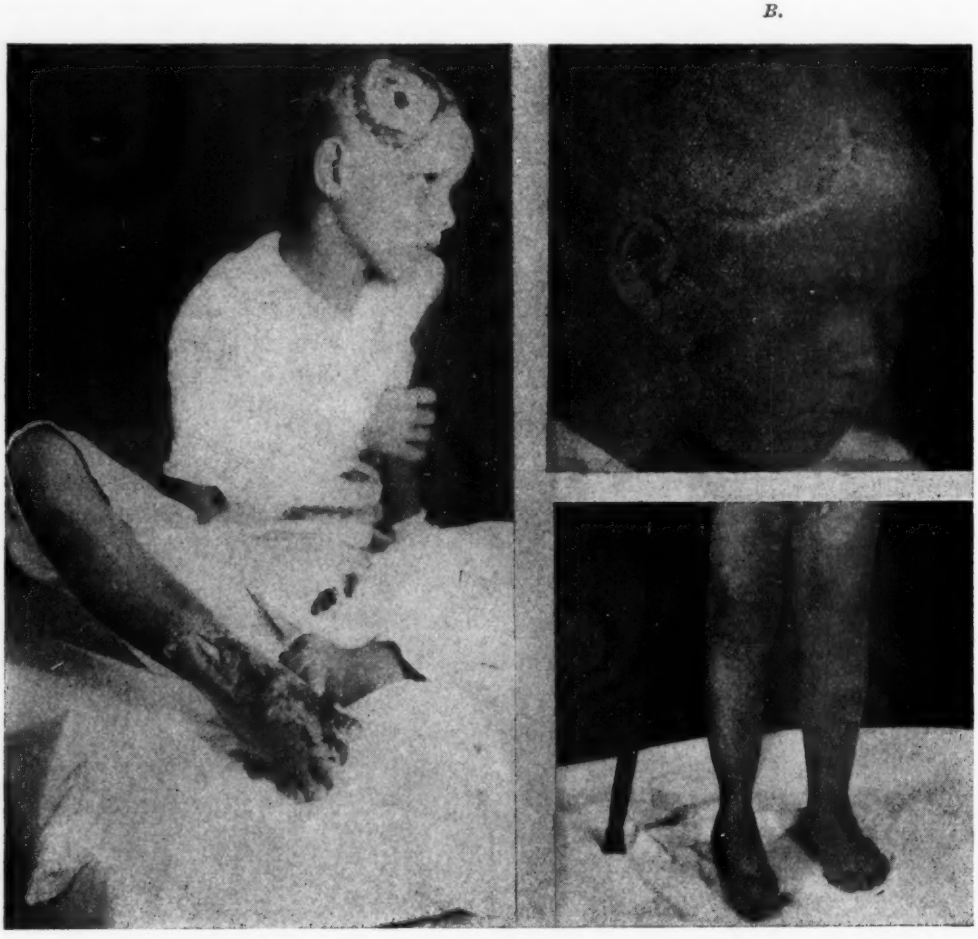
ANALYZATION OF CASES

On analyzation of our series of 97 cases, we find it a little difficult to classify them into groups in many instances because of the individuality of the lesion we were attempting to cover.

Skull Flaps.—The 5 cases of uncoverage of bone of the head fall fairly definitely into type where a sliding or rotation flap of the scalp is used to cover bare bone after removal of the external table of the skull (3 cases) or even the bare dura (1 case) (Fig. 1), or an open sinus (frontal, 1 case). The periosteum of the area from which the skin flap was removed is then covered with a substitute skin graft. In such cases the procedure was a one-stage affair and was in each case successfully accomplished.

Finger, Hand, Arm Flaps.—In 27 cases where a flap or flaps (4 instances) were transferred to either the fingers (Fig. 2), hand (Fig. 3), or arm (Fig. 4), most commonly from the abdomen (26 times), but in 2 instances from back to hand, and in 2 instances lateral chest to arm or elbow region, the operation was a one-stage affair save severance of the pedicle in all but coverage of the elbow, where a tubed pedicled flap of considerable length was deemed necessary. Seven of these flaps were bipedicled or pocket flaps and the remainder were unipedicled with a broad base. In 3 of the latter group the flap did not hold. One of these was a small deep irradiation ulcer of the back of the hand. The other two were to tips of the fingers, one in a small child. It has been found extremely difficult to attach a flap to a small child's finger unless the finger is well pocketed, as often a small child will wiggle his fingers in spite of pain and the fixation that is obtainable. The etiology of these injuries is as follows: 14 were due to some

type of trauma (2 ununited fractures of the leg, 6 to excessive irradiation, 5 were mangle burns, 4 electrical, 1 gunshot, and 1 was due to an ulcer caused by an improperly applied cast). In 9 instances traumatic amputation stumps of the fingers or end of the hand were covered. One case was a quite extensive and deep electrical burn of the shoulder (Fig. 5) which destroyed the deltoid muscle and exposed the shoulder joint. In the correction the shoulder joint was ankylosed and a large flap from the scapular region was turned over the exposed joint and upper humeral region after the dead cortex was removed.



B.

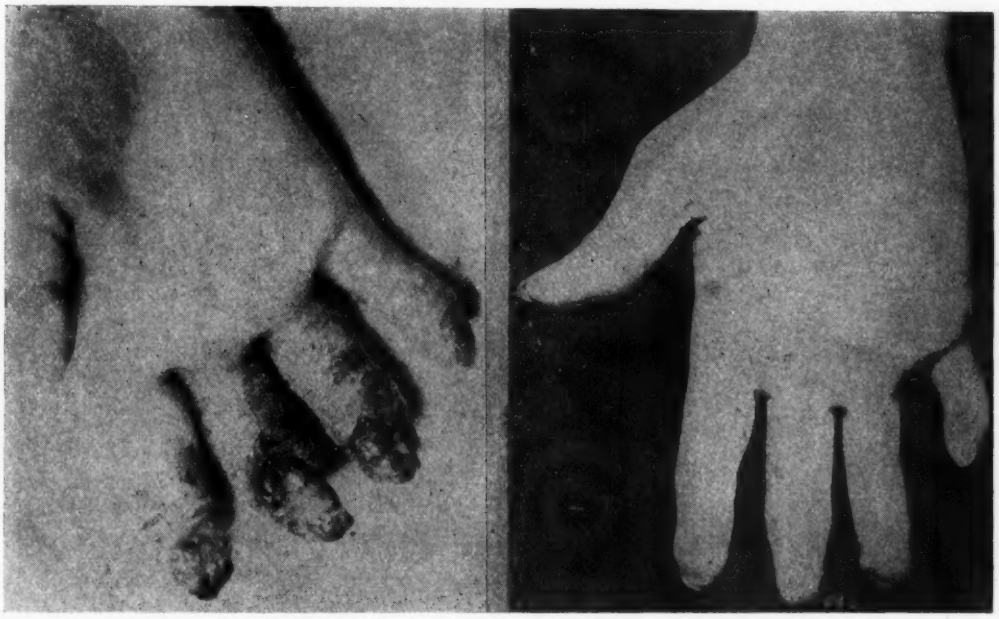
A. *C.*

Fig. 1.—This boy sustained an electrical burn which involved particularly the right side of the head and the right dorsal lower ankle and foot. The burn was deep enough that the whole thickness of the skull sequestrated. Most of the anterior tendons of the foot sloughed and the bone was uncovered. After about three months the sequestrum of the skull was removed. A large flap from the scalp was thrown from the opposite side of the head to cover the denuded dura. A skin graft was placed on the area from which the scalp flap was removed. This all was done in a one-stage fashion. Later a cartilage transplant from the chest was imbedded beneath the skin flap in such a manner as to overlap bevel fashion the skull edges to give a firm and rounded skull. During this interval after the dead tendons had been removed and the soft tissue had granulated in, somewhat, a skin flap from the opposite calf was placed anteriorly over the lower part of the ankle and dorsal part of the foot. This was also done in a one-stage manner.

A shows the original lesion. *B* shows the final head result. *C* shows the final foot repair.

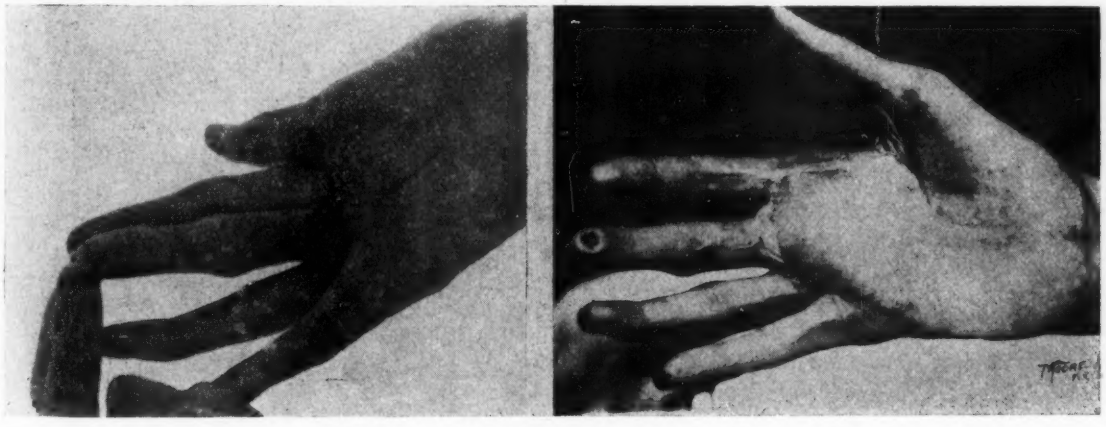
Body Flaps.—In the body region were 2 cases of exceptional stubbornness due to intensive irradiation, 1 over the sacral region (Fig. 6), in which a combination of two lateral buttock flaps and a skin graft (4 operations) finally resulted in coverage and relief of pain; the other was an excessive irradiation burn of the groin, lower abdomen, and upper thigh in which three flaps were attempted (1 abdominal flap, 1 thigh flap, and 1 scrotal flap). Each was delayed

before transfer and each sloughed somewhat. Finally septicemia developed, which resulted in a purulent knee joint infection, necessitating amputation. He finally recovered. Operation in the third case was done successfully in one stage by means of a bipedicled upper abdominal flap lowered to the lower abdominal wall after excision of the painful irradiation area. A skin graft was placed in the defect left after removal of the flap.



A. *B.*

Fig. 2.—*A*, A hand which had the distal phalanges destroyed by a mangle. To give padding and to increase the length of the fingers somewhat, flaps from the abdomen were applied to the finger tips. The greater part of the damage was on the ventral surface. *B*, Final result. (From Padgett, Earl C.: Skin Grafting, Springfield, Ill., 1942, Charles C Thomas, Publisher, p. 80.)



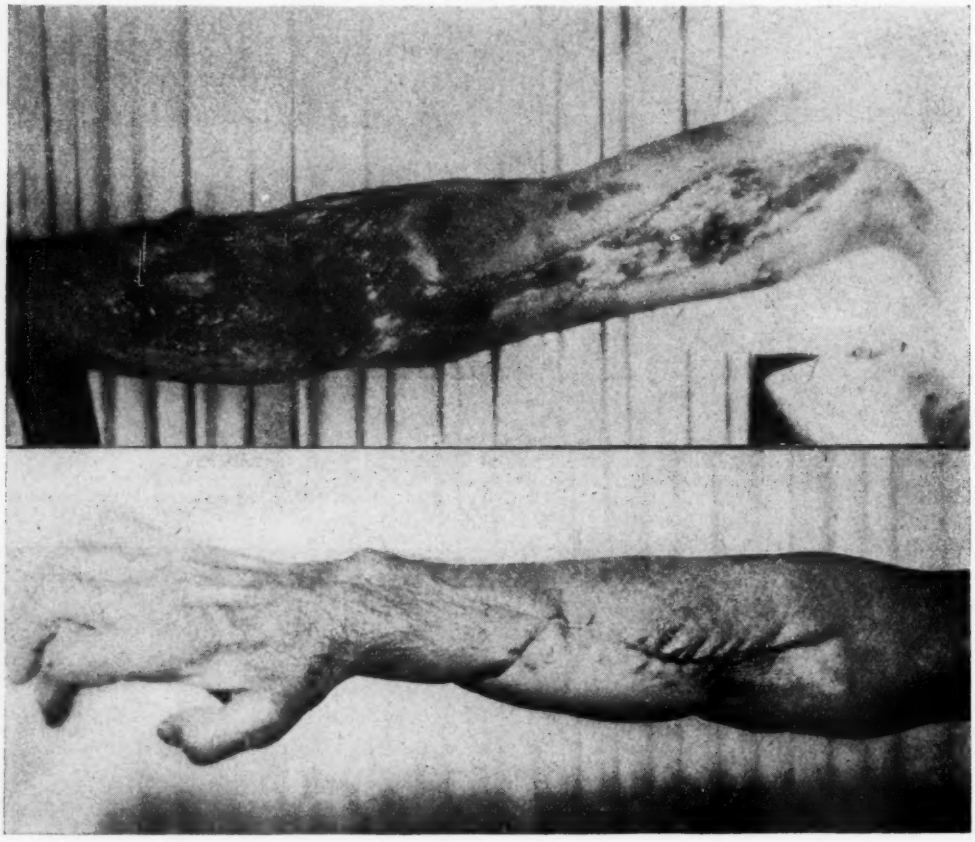
A. *B.*

Fig. 3.—*A*, A contracture of the hand in which at operation the tendons were laid bare. A skin flap from the abdomen was laid across the palm. *B*, Result one year later. (From Padgett, Earl C.: Skin Grafting, Springfield, Ill., 1942, Charles C Thomas, Publisher, p. 76.)

Lower Extremity Lesions.—Of the lesions about the thigh, leg, and foot, the etiology of the lesions ran about one-half due to some trauma. Of the other one-half, one-third was due to osteomyelitis, about another one-third was due to a burn, and a final one-third was due to excessive irradiation for some previous lesion. One was due to a frozen foot and one was a trophic ulcer.

Thigh Flaps.—The 13 cases in which flaps were removed from the thigh fall into two classes, one simply a routine affair where the transfer was simple such as delayed transfer from one thigh to the opposite foot (5 cases), sliding laterally over or down over the knee joint in one stage (2 cases), and in one case a delayed or tubed pedicled flap was transferred from each thigh to an opposite leg stump to cover a bilateral below-the-knee amputation (1 case). In a second case a tubed pedicled flap of the thigh was used to cover the end of an amputation stump in a boy with a short below-the-knee amputation. In this case the result has been satisfactory for about ten years. In 2 cases a thigh flap was transferred directly for the purpose of covering a foot defect. In one of these cases the defect was an irradiation ulcer of the whole of the bottom of the foot

A.

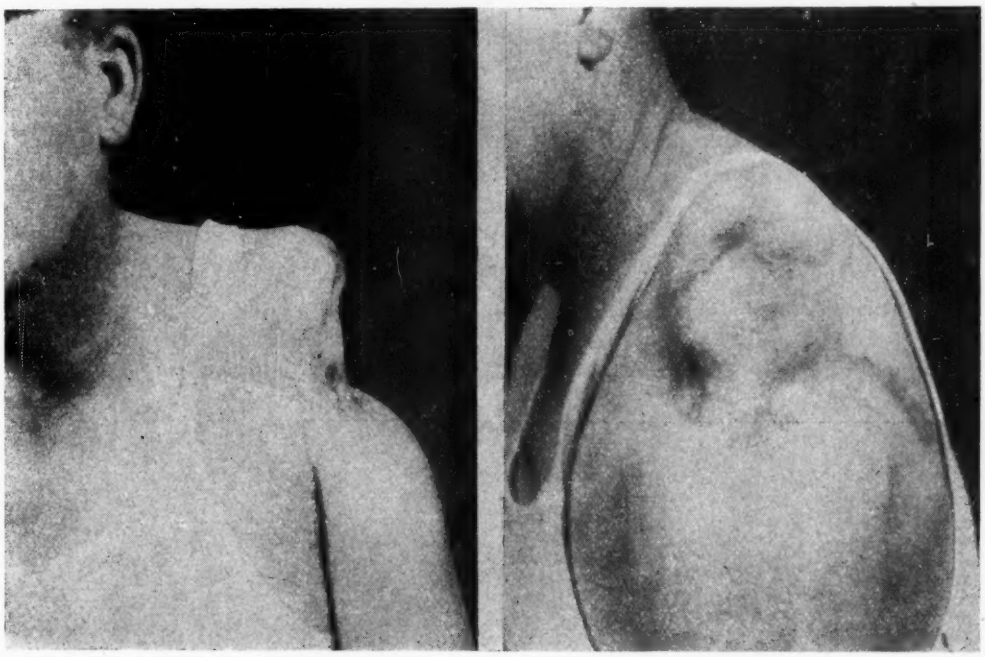


B.

Fig. 4.—*A*, This man fell through a greenhouse roof into a manure pile beneath. He was cut across all of the flexor muscles of the forearm and down to the medial nerve. Originally the wound was closed by another surgeon. The patient developed a gas gangrene and the muscles of the arm were laid wide open. The blood supply to the medial nerve was compromised, at the time of the second operation, so that he developed a temporary medial nerve paralysis but eventually the medial nerve regenerated and function became fairly good. To cover the large defect in his arm a large flap from the abdomen was transferred over the defect. A skin graft from the abdomen was applied to the area from which the flap was removed. *B*, Several weeks after operative procedures.

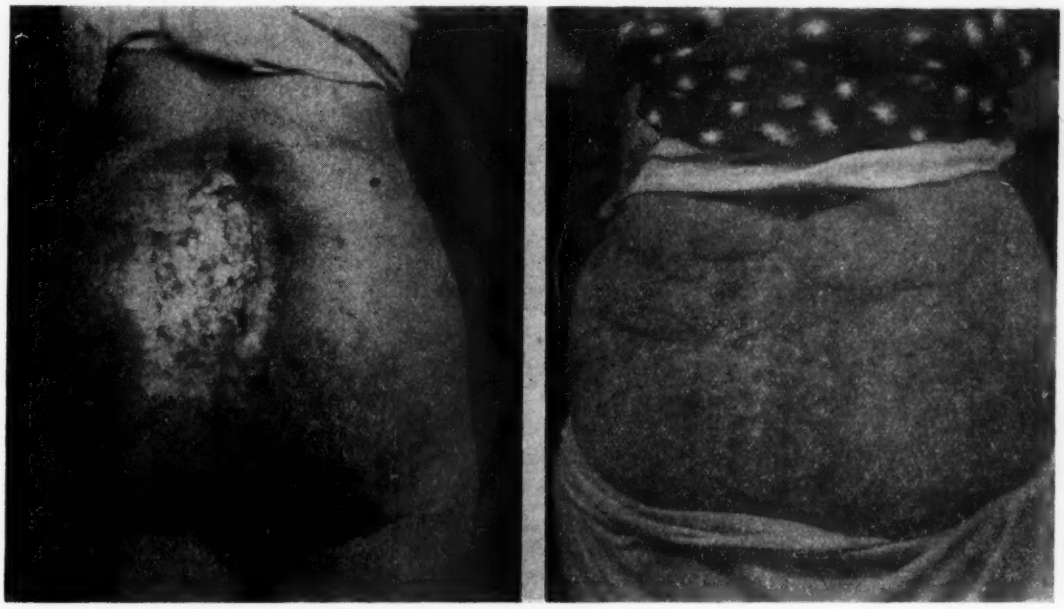
in a woman who originally was supposed to have had a fungus infection. In one case a scarred deformity of the knee was covered by means of a tubed pedicle flap. In a final instance we tried unsuccessfully to cover the exposed bone of the anterior tibial region due to a burn, by means of a reversed tubed pedicle flap taken from the opposite thigh. The distal end of the reversed flap sloughed. We then tried to jump the flap and were also unsuccessful with this.

Leg Calf Flaps.—In this series the skin flaps taken from the calf of the leg and transferred to the opposite anterior tibial region (Fig. 7, *A* and *B*), when the ulcerous area was not too large, the malleolar region (Fig. 7 *C*), the anterior



A. *B.*

Fig. 5.—*A* and *B*, This patient suffered an electrical burn across the shoulder, which destroyed the deltoid muscle and opened the shoulder joint, exposing the upper end of the humerus. After an interval of time the cortex of the upper end of the humerus was removed. The shoulder joint was ankylosed and a large skin flap was turned from the scapular region to cover the bony defect in the region of the joint of the upper end of the humerus. A skin graft was applied over the scapular area from which the flap was removed.

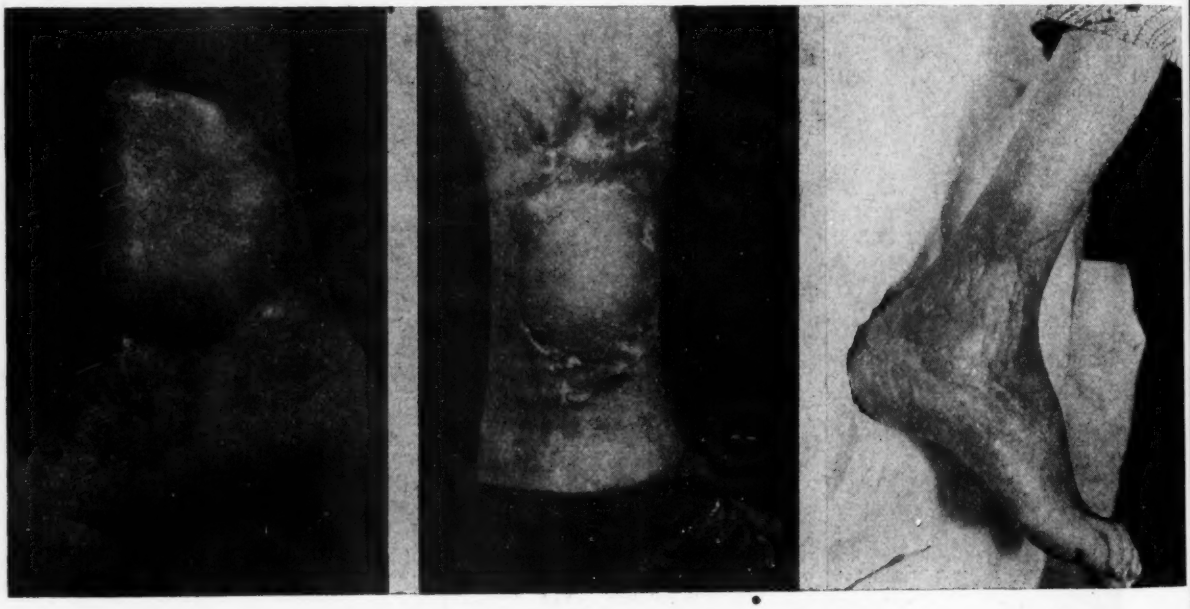


A. *B.*

Fig. 6.—*A*, This woman sustained a very severe x-ray burn of the sacral region from ill-advised deep therapy for menorrhagia. She had severe pain and some ulceration. A flap from the side of the buttocks was turned in over the sacral region. A skin graft was used to cover the area from which the flap was removed and on a place or two on the sacrum we were able to get a skin graft to take. Complete healing and relief of pain was obtained. *B*, Final result.

foot, over the end of a foot stump, the Achilles tendon region, the heel and bottom of the foot, or great toe are the most typical. In 45 cases, 49 flaps of the calf were transferred. In only 3 of these cases was the flap delayed (one six days, one ten days, one thirteen days). Delay was deemed wise because of a leg too fat, scar, or arterial damage. In the remainder of the group transfer was direct. Of this latter group of direct transfer, 2 were lost because of buckling of the base of the flap due to an improperly applied cast (1 complete, 1 partial). In the one partially lost, 5 days later the flap was extended upward, the cast reapplied, and a successful result obtained. In 5 other cases a partial loss of the flap occurred but after the pedicle of the flap was cut long and rotated somewhat, the result was successful coverage. In one case a flap was transferred over the top of each foot and over both Achilles tendon regions in 4 operations not counting the operation for the flap severance (Fig. 8).

As previously mentioned, it is particularly in this group of cases that we believe direct transfer may save much time and many operations for the patient.



A. *B.* *C.*

Fig. 7.—*A*, A patient with a large ulcerating ulcer of the lower anterior tibial and malleolar regions which had not healed for several years. The area was covered with a flap with good result.

B, A patient who had an ulcerating area over the tibial region with nonunion following a fracture. For some reason after a flap was applied over the area the fracture united and the result was good.

C, A patient with an ulcerating area over the external malleolar region. A flap was applied over the area from the opposite calf. In all of these cases the transfer of the flap was carried out in one operation and a skin graft was applied over the area from which the flap was taken on the opposite leg.

One criticism we feel should be made of the calf as a donor site when it is possible to use the anterior, medial, or posterior thigh region in as easy a manner as the calf, is the resultant scarring of the donor area in spite of the application of a skin graft. In a woman this may be objectionable. Often it is preferable to cover an area such as the heel, the external malleoli, or the Achilles tendon by means of a skin flap from the anterior thigh as the flap need not have a long pedicle. To cover the external malleolus, anterior foot, or external tibial region, considerable length to the flap may be required. In such a case the skin flap should be delayed in such a manner as not to jeopardize the blood supply when it is transplanted.

In 4 cases, with nearly the full length of the anterior tibial bone exposed, a bipedicled lateral flap was raised after a relaxing incision was made in the posterior calf region. The flap was then brought forward and sutured to the opposite skin and subcutaneous tissue. A skin graft was then placed in the relaxation defect. In only 1 was the result entirely satisfactory. One became infected; in the other 2 there was partial central loss of the flap which necessitated flap transfer from the opposite calf to give coverage.

CUTTING OF THE FLAP AND FIXATION

To make direct transfer successfully from calf to leg or foot, the calf flap should be cut in the line of the blood supply, with the base upward. When cutting a flap to cover an area on either arm or leg the base should be as wide as possible, the length of the flap must be fairly short, and on the leg the flap should always be taken over the muscular area posteriorly or laterally. A skin graft cut with the dermatome from the abdomen or thigh is applied immediately to the denuded area from which the flap is taken and a proper pressure dressing

A. *B.* *C.*

Fig. 8.—This child had suffered a destructive lesion of the anterior part of both feet and over the Achilles tendon due to a loop traction allowed to stay on too long after a fracture of both femurs. In this case we transferred four flaps, one to the top of each foot and one over each Achilles tendon. Each flap was transferred in one operation and a skin graft was placed over the area from which the flap was removed. The flaps were removed from the opposite calf each time and a successful result was obtained.

A, Anterior part of the feet before flaps were transferred. *B*, shows the flaps transferred. *C*, shows the flap over the Achilles tendon.

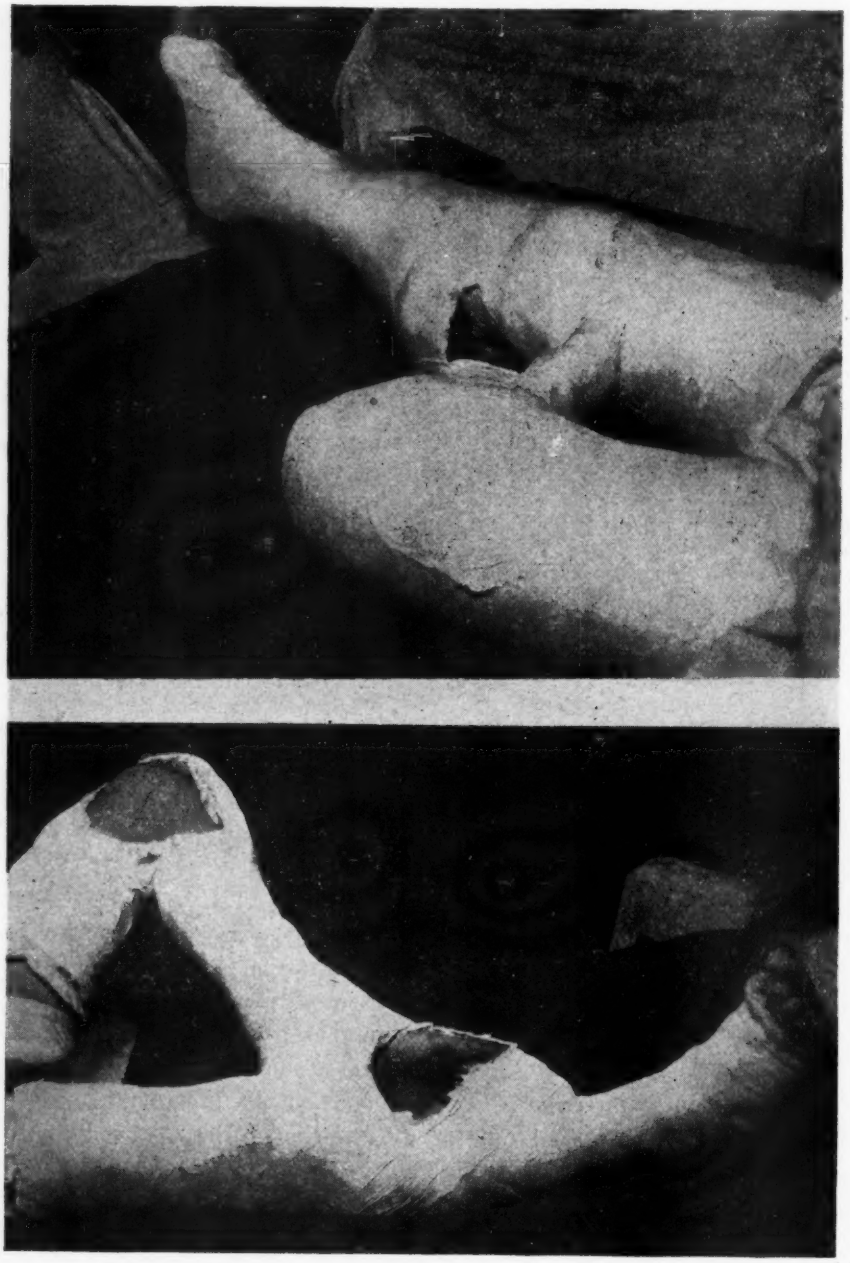
is applied over the skin graft. The ulcer base and surrouding scar are removed. Previously, as a rule, all slough, dead tendon, fascia, or bone should have been removed and the base rendered as nearly sterile as possible by means of repeated wet dressings. However, in some cases a completely aseptic wound is not obtainable. The resistance of a skin flap to infection is such, however, that with reasonable precaution in so far as infection is concerned, no difficulty in union will be encountered. Later, especially in the application of the cast, complete asepsis in so far as the flap is concerned is difficult because the flap should be kept under direct vision when it is being stitched in place and when cast or other fixation is being applied if deemed advisable. To hold the arm and hand to the abdomen, adhesive strips are usually adequate. There can be no tension; if the pedicle is rotated it must be a very loose twist. Of course, no pressure can be allowed on

the pedicle after the fixation is applied. Considerable ingenuity as to cutting the flap is required. When transferring a flap from one leg to the other the proper application of the cast is really the sine qua non of the procedure (Fig. 9).

PLANTAR DEFECTS

The common case of this type that one sees is caused by excessive irradiation of a plantar wart or corn. For one case in particular of an irradiation burn in a woman involving the whole of the bottom of the foot, a large lateral flap from the internal thigh was transferred directly, and for some of the fairly large defects of this nature a calf flap was used. These are listed in the preced-

A.

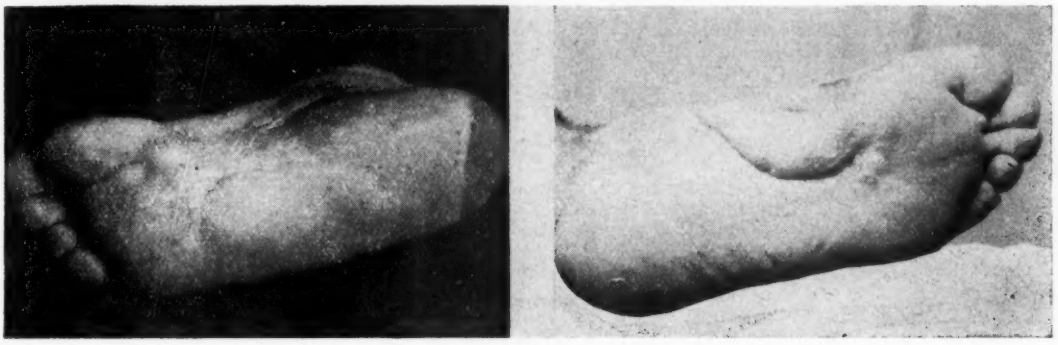


B.

Fig. 9.—Examples of cast application. *A*, A flap from the calf of the opposite leg is being turned over the internal malleolus. *B*, A flap from the opposite leg is being transferred to the bottom of the foot.

ing group (Fig. 10). In 3 instances it was possible to rotate a flap from the bottom of the foot in such a manner that the defect was covered. These were all cases where the defect was relatively small and located under the first metatarsophalangeal joint.

Brown,[11] 1944, has stressed the factor of lack of nerve supply after skin flap transplantation to the foot. Theoretically, a patient should not walk on the flap until a nerve supply has developed but by use of crutches or a cane and later by careful padding with foam-latex or neoprene pads in the shoe, plus care to avoid too much trauma or extremes of temperature and attention to cleanliness, atrophic ulceration usually will be prevented from developing. In one of our cases a wart formed between the keratosic normal sole and the flap. This was excised and did not recur.



A. *B.*

Fig. 10.—Example of hard scar of the inner plantar surface of the foot. There had been some loss of the first metatarsal bone and the lesion was painful and uncomfortable. The scar was excised and a flap from the opposite calf was transferred over the area. The patient obtained considerable relief on walking. *A*, Before, *B*, result after application of skin flap.

CONCLUSIONS

1. It is emphasized that often a skin flap can be transplanted to the opposite leg, ankle, or foot with safety from the calf or thigh region and the resultant aseptic denuded base from which the flap was removed covered by a skin graft at the first operation, thus saving time and a considerable number of operations.

2. For a traumatically amputated extremity which exposes bone without sufficient soft tissue for coverage, it may be wise to pad the end or the side of the bone with a skin flap if the maintenance of length or lateral padding is desirable. This may be true particularly for the hand and fingers and it is obligatory if one is reconstructing a thumb by use of a bone graft.

3. When tendons in such a location as the hand, fingers, or foot are exposed or if a joint in any location is opened, it is desirable to get immediate coverage by means of a skin flap.

4. Following a severe burn of the hands and fingers, a skin flap may be preferrable to a skin graft. In most instances, however, the demand is for the thinner coverage of the skin graft.

5. When a wound has caused loss of the deeper structures including muscle, nerve, and bone, and if reparative operations are contemplated in the future, coverage by a skin flap usually is necessary.

6. If an ulcerated area persists over large tendons such as the Achilles tendon, over bone such as the tibia, the malleoli or top of the foot, the application of a skin flap is desirable.

7. Over the heel and the first metatarsophalangeal joint, if the skin and subcutaneous tissue are absent, a skin flap is necessary because of the trauma to be sustained but great care is necessary for many months until a nerve supply is developed.

8. Over certain areas excessively irradiated with resultant ulceration and pain, especially if the base is of a fibrous nature, the chances of a skin graft taking may be nil or minimal, but after proper excision in most instances a skin flap will become attached and alleviate the discomfort.

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PRACTICAL ASPECTS OF THE TREATMENT OF BURNS

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WE OFFER no apologies, in the presence of the recent voluminous literature on this subject, for presenting certain factors from our experience with burns at the Beekman Hospital which we believe may be of help to others who have to treat these lesions.

The problems presented by burns have been of outstanding interest to one of us (D. G.) for thirty-five years, and, thus, it is of the greatest interest to note the success recent developments have made in preserving lives by plasma, transfusion, fluids, etc., until the vicious cycle of shock and hypoproteinemia has been broken, allowing the victim to survive and permit healing of his wounds.

It is our purpose to present procedures and observations which, though apparently duplicating published methods, we will emphasize wherein they differ and what we feel are advantages.

The Beekman Hospital Ambulance District embraces a large section of downtown Manhattan, affording a cross section of an old Metropolitan City, buildings from the oldest to the newest, with social and economic strata embracing the Bowery, Chinatown, and the financial center of Manhattan. There is a very high atmospheric dust content from steam plants and industrial activity, contaminated from unclean streets, horse trucking, fish markets, shipping, etc. Many of our victims come from lodginghouses and small industrial

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plants not under the sanitary supervision of welfare personnel. Victims from such sources lacking facilities for simple cleanliness present a background for gross contamination of any wound at its reception, to which is commonly added malnutrition and alcoholism with vitamin deficiencies.

In the presence of such possibilities for wound contamination, it is our present belief, from our experience with so little clinical evidence of infection, that burns are relatively clean wounds immediately after the burn has occurred and remain so until contaminated by a source of infection, such as the handling of the patient and the means taken to extinguish the flames of burning garments by rolling on the floor, in rugs, etc. In a case of an explosion where all or a greater part of the clothing is blown from the body, especially over the burned area, or where the exposed parts, as face, neck, hands and arms are burned, it appears to us that a degree of heat which will produce a severe second or third degree burn will destroy surface infection in a measure comparable to the destruction of the tissue which is injured, and infection is largely due to subsequent contamination.

We subscribe most definitely to the immediate covering of burned areas with sterile dressings where normally exposed surfaces are burned. This can be, and is, done from the first-aid ambulance kit. In extensive burns with the clothing destroyed in whole or in part, we believe in our ambulance attendants covering the victim quickly with one or two sterile sheets before covering him with the ambulance blanket. These sterile sheets are carried in a sterile package in the ambulance for such cases and afford a large degree of protection from immediate contamination from the ambulance blanket, which is a potent source of infection even though relatively clean.

When the patient is brought to the emergency room, the surgical staff and charge nurse on the floor are notified. It is the duty of the nurse to direct preparation of the burn bed and have in readiness, at the bedside, the "burn cart" which will be described in more detail later. The surgical staff makes its appraisal, and decisions are made as to the urgent needs of the patient. Morphine, in sufficient dosage to control pain, is given immediately. Shock therapy or prophylaxis should begin at this time in the more serious cases. While the patient is on the stretcher at the bedside, all clothes are completely removed before he is placed in the burn bed. All personnel wear sterile gowns, gloves, caps, and masks. The patient also wears a cap and mask where the forehead and head are not burned. Necessary laboratory procedures are then carried out. Plasma, transfusions, fluids, and electrolytes are given, according to the need as determined by laboratory and clinical findings. In the extensively and critically burned who are on the brink of profound shock, it may be harmful to subject them to the painful and shock-producing procedure of extensive cleansing and débridement. It is advisable in these cases to apply immediately the "petrolatum poultice." In all others, simple cleansing and removal of loose tissue is carried out before the poultice is applied. The cleansing, with the use of detergents when indicated, includes a considerable area beyond the involved portion. An accurate estimate of the extent and probable degree of the burn is recorded.

The procedure to be used following the preliminary preparation depends on the extent and depth of the burn, together with the temperature outside. In cold weather petrolatum poultices with supporting pads may be used freely. In hot weather, where the extent of the burned area calls for so complete a covering of the body with heat insulating dressings, one can add insulation heat stroke to burn toxemia, as exemplified in one of our patients with third

degree burns from midthighs to ankles, and second degree burns of the body from umbilicus to and including face, neck, and arms, who recovered with a minimum covering of the burned area. The outside temperature was 90 to 94° F. for over two weeks. One must not overlook the fact that the Cocoanut Grove disaster occurred late in November when swaddling dressings might be desirable for warmth. Under high outside temperatures the dressings are reduced in extent to a minimum with petrolatum poultices to the third degree lesions. The patient is placed on a sterile sheet under a tent arranged for controlling the inside temperature, to which is added a fly net.

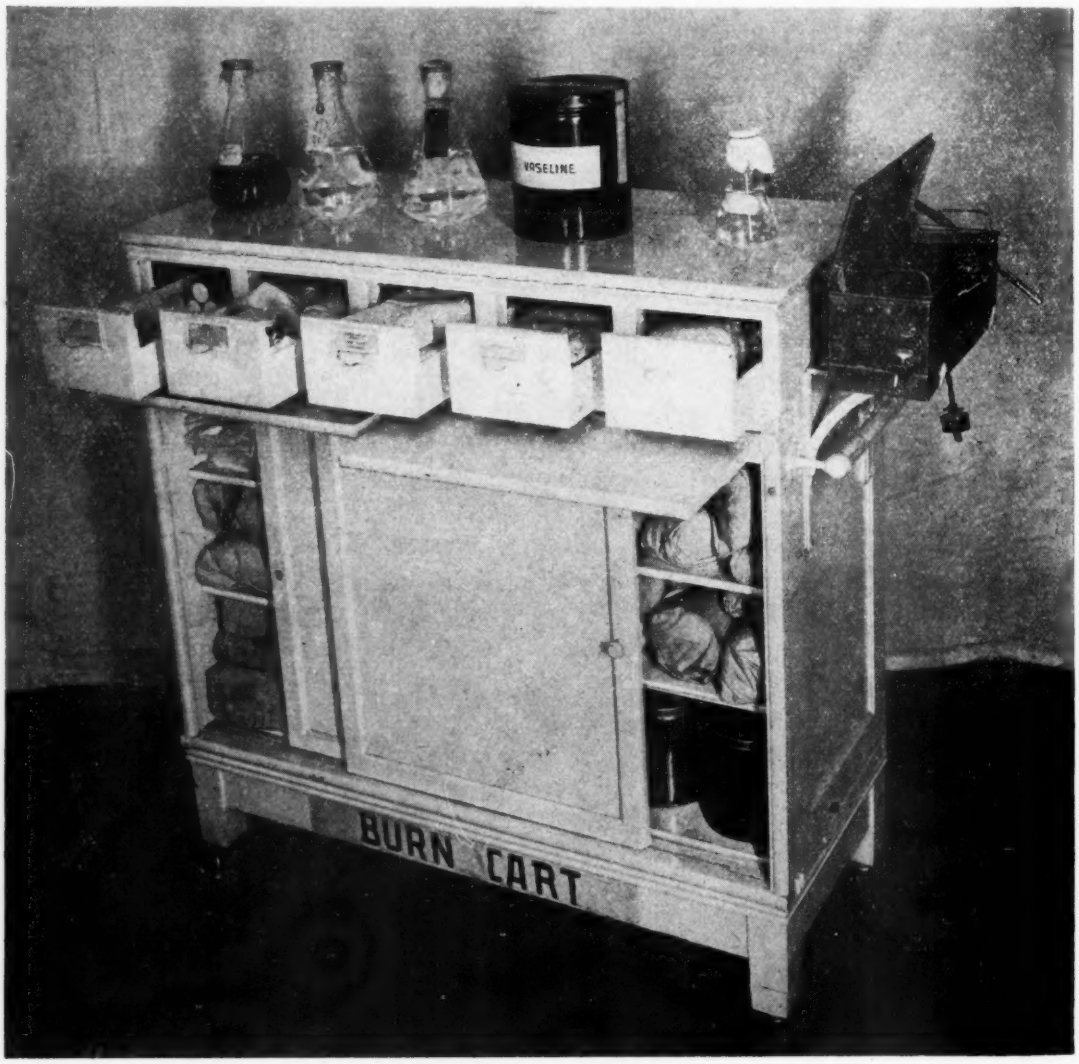

Fig. 1.—Beekman Hospital burn cart.

The "burn cart" was conceived by one of us (L. V. M.) and its contents determined with the same idea behind its use as the well-known "fracture cart." It should be large enough to hold a complete supply of materials for the treatment of several serious burns simultaneously. It should be mounted on wheels swiveled at one end so that it may readily be wheeled where needed. Fig. 1 shows a burn cart we have constructed from an old wooden cabinet. It stands 44½ inches high, 43 inches wide and 17½ inches deep. Fixed to one end is an electric sterilizer for heating our unguents or sterilizing instruments. On the

flat top is arrayed sterile solutions in flasks. Six drawers just under the top contain the numerous smaller items, with an index of contents on the front of each one. Just below these are two sliding work shelves. The lower portion contains the bulky sterile items enclosed by sliding doors. Following is a list of contents:

Sterilizer	Carbon tetrachloride 500 c.c.
Mineral oil, 2 liters	Castor oil, 2 ounces
Detergent solution	Vaseline gauze, 2 tins
Boric acid solution, 250 c.c.	Boric acid gauze, 2 tins
Cotton waste, batting	Sterile leg roll, 1 dozen
Sterile gloves	Gauze pads 4 by 4 inches, 10 packages
Instruments	Gauze pads 2 by 2 inches, 10 packages
Sulfanilamide powder	Green soap
Masks and caps	White soap
Adhesive	Sterile gowns, 3
Safety pins	Combines, 12
Knife blades	Boric acid ointment, 5 pounds
Bandages, 3, 4, 5 inches	Petroleum, 5 pounds
Bandage scissors	Tongue depressors, 4 dozen
Boric acid solution, 500 c.c.	Irrigating cans
Benzine 500 c.c.	Sterile bed linen
Alcohol 70 per cent, 500 c.c.	Sterile basins
Peroxide 500 c.c.	Sterile bandages, 3 to 4 in., 3 dozen

We highly recommend a cart of this type for use in the acute hospital when one or more burn cases are admitted.

The most important and immediate consideration is the prevention and treatment of shock. To this end, morphine in adequate doses, with due consideration for youth or old age, should be given. One-half grain should be the initial dose for adults. This may be repeated in one hour, each specific dose being ordered as necessary. Usually after preliminary sedation, one-quarter grain every three or four hours will suffice. Where involvement of the respiratory tract is suspected, morphine in small doses may be given for other direct indications. The loss of plasma from the burned surface may be huge. This must be replaced from external sources. Where possible and indicated, it is wise to begin the administration of plasma on admission. Conceivably some severely burned individuals may not show a great departure of their chemistry from the normal within one hour from the reception of the injury. However, all such patients receive plasma. A limited balance can be maintained by protein reserves and sacrifices by the uninjured tissues. Acute loss can be built up quickly by administration of plasma. One needle puncture may serve to secure the blood specimen for typing, hematocrit and to begin intravenous therapy. The hematocrit, falling drop, hemoglobin, and red blood count are the tests to judge the requirements of intravenous therapy. Burned patients do not need whole blood in the initial stages. Subsequent anemia will invariably develop at which time transfusions may be administered. Concentration of the blood, with the beginning of shock, tends to help establish a vicious cycle continuing stasis and anoxemia. We prefer to administer 100 c.c. of undiluted plasma for each point above 45 per cent cells on the hematocrit for the treatment and prevention of shock.[1] Marked difficulties still exist in deciding about the need for other fluids. Intravenous normal saline or 5 per cent glucose in distilled water may be given to encourage a urinary output of at least 1,500 c.c. in twenty-four hours. Chloride determination in the urine, if indicative of less than 4 Gm. of sodium chloride excretion in twenty-four hours,

shows the need for intravenous saline. The oral route for fluid intake is preferred and should be encouraged whenever possible. Coffee, weak tea, carbonated drinks, and fruit juices are excellent. Often during the early days of convalescence, inanition and loss of appetite develop, preventing the natural ingestion of food from aiding in elevating depressed plasma proteins. This further hinders the healing powers of the tissues. For these patients, we have tried to anticipate and have used a Levin tube through the nose into the stomach connected with a drip feeding of pabulum for prophylaxis against the development of low proteins. The formula is the same as is used in jejunostomy feedings in postgastric resection cases. We have found this to be dramatic in its efficiency.

We emphasize strongly that we feel burns at their inception are clean. Usually they do not require extensive cleansing unless obviously contaminated. Furthermore, a patient precariously on the borderline of impending shock may be seriously injured by overzealous treatment. For practical purposes we follow a simple plan. The more extensively and deeply burned, the less radical treatment. When the patient is covered with grease or dirt or has brush burns we clean lightly and irrigate with detergents and saline solution, using gauze sponges. Imbedded particles, especially on the face, should be removed. Detergents have been invaluable in limiting excessive scrubbing. Loose epidermis is removed. Blisters and intact skin are not débrided. The usual burn patient, on arrival at the hospital, receives systemic therapy and immediately has the boric acid poultice applied. Occasionally, the area may be lightly dusted with sulfanilamide powder. Sulfadiazine or one of the other sulfonamide drugs with equal or somewhat greater amounts of the alkaline salts are invariably administered by mouth.

Where burned areas are to be exposed they are covered with a layer of petrolatum or borated petrolatum to a thickness of one-third of one inch, using a sterile rubber glove on the hand to apply it. If the surface is too moist from exudation and difficulty is encountered in getting the ointment to adhere, the grease should be put in a sterile container, such as a small sterile pitcher, and heated to a degree where it will not run too freely, and when poured will set as soon as it strikes the moist surface. The temperature should not be of a degree to cause the least discomfort to the patient. As the ointment sets it should be built up to one-fourth inch thickness and kept there continuously. In using a borated petrolatum, or where a medicament is in suspension in a grease base, one must be careful to avoid precipitation of the drug by too great a degree of heat. If such occurs, cooling in a water bath of ice water while it is stirred with a sterile tongue depressor will restore the suspension. This procedure works excellently on second degree burns of exposed parts of the body such as face, neck, hands, and forearms. In extensive second degree burns of the body including trunk and back, as the ointment melts and runs down onto the sterile sheet, a most perfect petrolatum pressure dressing is afforded the back, with compression under which condition epithelization is rapid.

In cases of third degree and deep second degree burns where there is complete epithelial loss between the glandular epithelium, we find that using borated or petrolatum gauze, in the form of what we have called a petrolatum poultice, affords the greatest comfort to the patient, requires infrequent dressings, apparently diminishes lymph loss, and promotes epithelization in a way which exceeds any other technique we have tried. It should be understood that this will not take the place of skin grafting, but from our experience, it helps develop the quickest and healthiest granulations, while the slough is separating,

affording a base for skin grafting on third degree areas while promoting and protecting epithelization on nearby areas of second degree lesions.

A criticism of the thick petrolatum dressing or poultice might be that it macerates tissue by preventing the exudate from being absorbed by the dressings. In answer, we would state that, except in the case of a clean sutured incised wound of the skin, we are unable to recall any healing process which takes place in the body without the presence of tissue fluids either infected or otherwise. Furthermore, we have not seen any maceration with this technique. In our experience maceration occurs only with the improper use of wet dressings.

The petrolatum poultice consists of enough pieces of petrolatum or borated gauze to form a thickness of at least three-sixteenths to one-quarter inch. This is not laid on piece by piece but in the thickness described. Furthermore, it is laid on longitudinally with overlapping edges and extending well beyond the burned area. These are covered with Dakin pads which are bandaged firmly and comfortably but not too snugly. The consistency of the poultice with the external dressings acts as a fair splint. We insist on elevation of the burned limb above the heart, and the upright sitting position where possible, for burns of the face, head, and neck, to diminish lymph loss and swelling. Controlling the swelling in this way, not only diminishes the lymph loss but also, with occasional dependent periods, promotes vascularity of the granulations and epithelization on second degree burns or following skin grafting by avoiding postural ischemia.

High caloric, high protein, high vitamin diet is given when tolerated. We make an effort to see the tray as it leaves the patient rather than when it is received. There should be no delay in noting loss of appetite, since many of these patients are already suffering from subclinical malnutrition. Serious decreases in protein may occur in a short time in these seriously ill patients with poor healing, general debility, and infection.[2] Intake and output of fluids should be recorded. Most important is a urinary volume of at least 1,500 c.c. with satisfactory specific gravity and about 4 Gm. of sodium chloride excretion in twenty-four hours. During periods of excessive humidity and heat it may not be practical to use the bulky dressings necessary with the present-day pressure dressing technique. Heat loss, both by radiation and evaporation, is impaired and may be the cause of heat stroke. Air conditioning apparatus would solve this problem. Scott-Ivy Pabulum, with forced intragastric feedings, may be used when loss of appetite interferes with satisfactory ingestion.

Dressings are done every three or four days when sloughs are present, a week or ten days otherwise, with reinforcement as necessary. The major loss of plasma continues for about twenty-four to thirty-six hours. Dressings should be snugged especially during this period and for a variable time thereafter. If infection, excessive odor, or lack of comfort results, the dressings may be removed for inspection. For pyocyaneus infection, we have used boric acid ointment. Where minute pustules appear in epithelized areas, we have found 1 per cent salicylic acid in boric acid ointment of great help when used locally over the pustule. The dressings slide off as soon as the bandages are cut, neither sticking, nor leaving any bleeding points, nor causing discomfort. Where sloughs are present, there will be an odor. The loose edges and centers of these sloughs are removed as indicated without causing any bleeding. In removing a dressing, a considerable exudate will be obvious. One should not look on this as an expression of infection, unless other signs of infection exist. The wound is irrigated with a detergent solution, weak peroxide and neutral soap, followed by saline solution. Except where sloughs exist, most of the odor will disappear

after cleansing. Infected burns are treated with the usual wet dressings as are other infections followed by early skin grafting when infection has subsided. We have not seen the need for bacteriologic studies to indicate when this may be done. Healthy appearing granulations have been a satisfactory guide.

To get an accurate evaluation of the degree of epithelization and its progress, the wound should be left exposed for a few moments until the surface moisture has dried slightly, then viewed with a magnifying glass using oblique illumination from a flashlight. Where a portion of the granulating area appears dry in contrast to an area obviously moist, one can be assured that the dry area is covered with a delicate epithelial layer, which is not apparent in the moist state. Commonly extending along the advancing edges of the new epithelium, there is a faint pinkish-red line. For many years, one of us (D. G.) has studied this pink line in determining the degree of advancing epithelium on granulating areas on patients. Howes[3] mentioned this red line observed in studies of epithelization on the rabbit's ear. If it is studied carefully under a magnifying glass, using oblique illumination, it will be seen that the line is formed by a slight concave depression below the surrounding surface. It has appeared to us that this depression is covered only by a single layer of epithelium, which restrains the underlying granulation tissue from becoming redundant at the edges of the advancing epithelium and interfering with its progress, an exceptional example of the inhibitory power of epithelium on granulation growth. Where this line exists, or where there are no redundant granulations, it is absolutely contraindicated to use silver nitrate. The expression one hears of using the latter to "promote granulation" is an absolute fallacy, as its action is entirely destructive. Unless there is an ischemia from underlying scar tissue, granulation tissue requires no stimulation other than that which nature affords. Before redundancy occurs, the marginal granulation can only be restrained by advancing the epithelium by dressings which will not adhere and destroy it on their removal. We find this can be done best by dressings containing an adequate amount of plain or borated petrolatum, to be followed by skin grafts as soon as the sloughs have separated.

Skin grafting is accomplished as early as possible. When the first dressing is done, an appraisal is made of the third degree areas. Second degree burns may be completely healed. Where slough is definitely slow in separating, surgical excision will greatly shorten the period of waiting. If clean areas alternate with infected areas, skin grafting need not be delayed on the clean areas. Pinch grafts insure the greatest degree of success but may only be used on certain portions of the body. If the individual grafts are placed closely together, the cobblestone effect will be diminished. The primary dressing for skin grafts is the paraffin mesh gauze with adhesive and covered with dry gauze. When the graft has adhered we use the petrolatum poultice to enable the epithelium to spread.

Before the sulfonamide drugs appeared, we used borated petrolatum in large amounts and still do for its ability to prevent pyocyaneus infection and its capacity of adhering to moist surfaces, when it is brought to the proper temperature. Though aware of is possible toxic action, we have not observed any.

We use one of the sulfonamide drugs locally and orally to combat infection, whenever we feel they are indicated.

Where applicable on limbs we have made use of the whirlpool bath to aid in separating sloughs and to improve vascularity under healed areas, which have been skin grafted as soon as they will tolerate moisture.

Contractures are combated by placing the limbs in extension and splinting them to prevent muscle spasm inducing contractures. If the dressings are voluminous enough they will sometimes be sufficient, provided they are made comfortable, which the thick grease dressing does. Where feasible, elevation is arranged by suspension from an overhead fracture frame, which permits movements, active and resistive, at the earliest possible time. We have used these "resisted" exercises in flotation to overcome muscle spasm and increase the range of motion of major joints. With the aid of pulleys at each end of the bed and light, graduated traction weights, the extensors and flexors are exercised alternately and independently. The value of this type of muscle exercise has been little appreciated. We have used them successfully in many types of injuries.

Such exercise tends to diminish all the factors which predispose to spasm, atrophy of tissue, and contractures, thus avoiding some of the sequelae of burns. The cooperation of the patient in doing these exercises cannot be obtained unless these movements are without pain or discomfort.

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MORTALITY FACTORS IN ACUTE APPENDICITIS

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ALL reports of patients with acute appendicitis operated upon at the Peter Bent Brigham Hospital in the years 1913 (when the hospital first opened its doors) through 1940 were reviewed in a previous publication.[2] It was surprising and disappointing that an analysis of mortality rates by five-year periods failed to show any appreciable improvement with the passing of time (Table I). Even during the last period, when much might have been expected of chemotherapy in this field of surgery, patients were lost despite heavy treatment with sulfonamides (Table II). Furthermore, the mortality figures do not differ greatly from those reported from comparable institutions (Table III).[1,3,4,5,6] The failure to improve with the passage of time stimulated a detailed study of all the fatal cases during this twenty-eight year period in an effort to shed further light upon factors in management which influence the mortality.

The series is a selective one to this extent: children under the age of 12 are not included; neoplasm or tuberculosis of appendix or cecum is excluded even if associated with acute infection.

There are 106 recorded deaths from acute appendicitis from 1913 through 1940 (Table IV). There were autopsies in 56 of the total deaths, or 53 per cent. Five patients had no operation and have been eliminated from this study; these cases actually prove only that a patient may die without operation, and con-

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TABLE I. ANALYSIS OF DEATHS FROM APPENDICITIS—MORTALITY RATE BY FIVE-YEAR PERIODS*

YEARS	TOTAL CASES	DEATHS	MORTALITY (%)
1913-1920	475	26	5.5
1921-1925	422	17	4.0
1926-1930	405	15	3.7
1931-1935	375	17	4.5
1936-1940	518	25	4.8
1913-1940	2,195	100	4.6

*Operative deaths only.

TABLE II. ANALYSIS OF DEATHS FROM APPENDICITIS—PATIENTS RECEIVING SULFANILAMIDE THERAPY

YEAR	AGE	SEX	TYPE OF APPENDIX	LOCATION	CATHARTIC	DURATION OF SYMPTOMS (DAYS)	PERITONEAL CULTURE	PERITONEAL SULFANILAMIDE	ADEQUATE DOSAGE	P.O. SURVIVAL (DAYS)
1938	25	M	Perforated	Iliac fossa*	No	5	B. coli	No	Yes	12
1940	69	M	Abscess (I & D)	Iliac fossa†	Yes	5	B. coli nonhem. strep.	No	Yes	7
1940	67	M	Perforated	Retro-ileal‡	No	3	B. coli	Yes	Yes	4

*Patient had a very toxic course
†Death from pylephlebitis
‡Death from progressive peritonitis

TABLE III. ANALYSIS OF DEATHS FROM ACUTE APPENDICITIS—MORTALITY RATES IN LEADING CLINICS*

AUTHOR	MICROSCOPIC CONTROL	ACUTE UNRUPTURED APPENDICITIS		ACUTE PERFORATED APPENDICITIS		APPENDICAL ABSCESS		TOTAL	
		CASES	MORTALITY (%)	CASES	MORTALITY (%)	CASES	MORTALITY (%)	CASES	MORTALITY (%)
Busch and Spivack, New York, Beth Israel Hospital, 1931-36	Yes	492	0.4	52	13.5	91	6.6	635	2.4
Davis and McLaughlin,† Omaha, U. of Neb. Hospital, 1932-1938	?	784	0.5	124	13.7	50	8.0	958	2.6
Reid and Montanus, Cincinnati, Cinn. Gen. Hosp., 1934-1938	?	583	1.0	209	17.2	129	10.1	921	6.0
Haggard and Kirtley, Nashville, Haggard Clinic, 1915-1938	?	2,007	0.6	189	24.8	417	5.8	2,613	3.2
Stafford and Sprong, Baltimore, Johns Hopkins Hosp., 1931-1939	?	838	0.0	196	14.2	283	7.1	1,317	3.6
Cutler and Hoerr, Boston, Peter Bent Brigham Hosp., 1913-1940	Yes	1,604	1.2	339	17.1	247	7.3	2,192‡	4.4

*Figures adapted and made comparable to those of Peter Bent Brigham Hospital.
†This series excludes entirely five moribund patients.
‡Total figure includes two anesthesia deaths.

TABLE IV. ANALYSIS OF DEATHS FROM APPENDICITIS—FATAL CASES

No operation	5
Operation at another hospital	1
Death in the operating room	2
Death from extra-abdominal causes	18
Death from progressing appendicitis	80
Total	106

tribute nothing to a study of operative management. In one instance operation was performed in another hospital and for this no responsibility is assumed. Two patients died in the operating room, presumably from anesthesia. Eighteen died from causes which are arbitrarily called *extra-abdominal;* in these patients the appendicitis was controlled as far as could be judged from the clinical course and from the autopsy when one was done (Table V). There remain 80 patients in whom death occurred as a result of unchecked appendicitis or its direct complications, that is, from *abdominal* causes.

TABLE V. ANALYSIS OF DEATHS FROM APPENDICITIS—EXTRA-ABDOMINAL CAUSES OF DEATH

Pulmonary embolism	9 (youngest age 45)
Pneumonia	2
Coronary occlusion	1
Diabetic coma	1
Hemorrhagic purpura	1
Diabetes and nephritis	1
Uncertain	3
Total	18 (6 younger than 50)

Cases have been placed in one of three groups: acute perforated appendicitis if a gross perforation was described either by the surgeon or by the pathologist; appendical abscess if the surgeon found localized pus; acute unruptured appendicitis if there was no localized pus or gross perforation. In all cases when the appendix was removed there was microscopic verification of the operative diagnosis.

The criteria for grouping described here are not without disadvantage, but they are simple and applied with relative ease. Many cases of severe appendicitis with gangrene, and even a general peritonitis with a positive peritoneal culture, have been placed in the unruptured group because there was no gross perforation; an appendix broken in removal has likewise been regarded as unruptured. This has been necessary to avoid inconsistencies in the estimate of the extent of the peritoneal involvement by the many different surgeons. Although the peritoneal culture offers an accurate means of determining the presence of infection beyond the appendix, it could not be used as a criterion in this series because of the infrequency with which cultures were taken fifteen or twenty years ago.

Attention has been focused upon the 80 patients who died of progressive appendicitis. It is reasoned that the *extra-abdominal* causes of death are common to all types of disease, medical as well as surgical, and cannot directly be related to factors in the management of acute appendicitis. In death due to *abdominal* causes, on the other hand, it must be assumed that in each instance, for whatever reason (not the least being delay in hospitalization), the appendicitis was inadequately treated.

The study has been developed in two ways: first, a consideration of the clinical aspects of the fatal cases; second, a modification of previously derived mortality statistics by excluding those cases in which death was not directly attributable to the abdominal disease, as in pulmonary embolism or coronary thrombosis.

ANALYSIS OF DEATHS DIRECTLY DUE TO PROGRESSIVE APPENDICITIS

Chief Clinical Features in Abdominal Deaths.—It is to be expected that the patients in the vast majority of these fatal cases already have advanced appendicitis at the time of operation. This is borne out by the fact that at operation 53 had perforations, 14 had appendical abscess, and only 13 of the

80 were unruptured. In Table VI is indicated in the order of frequency the principal clinical feature of the fatal cases cross-analyzed with respect to the findings at the time of operation. A peritonitis which continued to develop despite the operative procedure accounted for 22 patients; 17 died within fourteen days of the initial symptom. Next in frequency was the existence of two or more persistent and undrained abdominal abscesses; more than one-half of the patients (6 of 11) lived more than fourteen days after the initial symptom. Nine suffered from a serious extra-abdominal disease as well as progressive peritonitis: 4 had diabetes, 2 had heart disease, and 1 each had chronic nephritis, pulmonary tuberculosis, and massive pulmonary atelectasis.

TABLE VI. ANALYSIS OF DEATHS FROM APPENDICITIS—CHIEF CLINICAL FEATURE IN "ABDOMINAL" DEATHS, ACUTE APPENDICITIS

		TYPE OF APPENDICITIS		
	ALL CASES	UNRUPTURED	PERFORATED	ABSCESS
Progressive general peritonitis	22	4	17	1
Multiple abdominal abscesses	11	2	7	2
General peritonitis and serious extra-abdominal disease	9	2*	3	4
Fulminating or very toxic course	8	2	6	-
Arrived in hospital "moribund," in "shock," or as "very poor risk"	7	-	7	-
Severe ileus	5	-	3	2
Mechanical intestinal obstruction	5	-	5	-
Single abdominal abscess	4	-	2	2
Pylephlebitis	4†	2	1	1
Metastatic abscesses or pyemia	3	-	1	2*
Anesthetic death at second operation	2	1	1	-
Total	80	13	53	14

*Includes one case with incidental pylephlebitis.
†Two additional cases of pylephlebitis placed in other groups.

Patients whose course was fulminating, or who arrived at the hospital in a critical condition, are similar in that in these individuals the virulence of the bacterial infection appears to be the decisive factor. It is noteworthy that of the 15 patients included in these two groups, 13 had a perforated appendicitis, and 13 died within seven days of the onset of the disease.

The remaining fatal cases fall into clinical groupings which claim only a few patients in each: severe ileus, mechanical intestinal obstruction, single abdominal abscess, pylephlebitis, pyemia, and anesthetic death at a second operation.

If one looks at the data contained in Table VI with the coldly suspicious stare which surgeons employ when scrutinizing the mortality figures of others, an impression is obtained that certain of these patients might have been saved. Perhaps the 10 patients who died from severe ileus or mechanical intestinal obstruction would have lived had they had prompt and efficient gastrointestinal siphonage, an operative freeing of adhesions, or an enterostomy at the proper time. (Three of them actually did have unsuccessful secondary operative procedures.) The abscess should have been suspected and properly drained in the 4 patients who had a single large residual abscess and possibly some of the 11 patients with two or more abscesses could have been saved with judicious use of the scalpel. (Only 5 of the 15 in the combined groups with residual abscesses had secondary incision and drainage.) The 2 patients who died of anesthesia at a second operation might represent a lack of care either in the choice of anesthesia or the preoperative preparation. One cannot generalize without further data concerning the remaining 53 patients who died of progressive peritonitis, who had violent bacterial infection, or who developed pylephlebitis or pyemia.

Promptness of Operative Treatment.—It has long been recognized that delay in operation when acute appendicitis is in its early stages is perhaps the greatest single factor contributing to mortality; the generally accepted reason is that delay permits the complications of free perforation or abscess formation to take place. Only 13 of the 80 patients were operated upon within the first 48 hours of the disease. In Table VII the operative findings are described as related to the duration of the disease. This table merely notes delay and does not assign the blame to patient, physician, or hospital. Of interest is the fact that unruptured appendicitis was found as late as four days after the initial symptom in two fatal cases.

TABLE VII. ANALYSIS OF DEATHS FROM APPENDICITIS—OPERATIVE FINDINGS RELATED TO DURATION OF SYMPTOMS

DURATION OF SYMPTOMS TO OPERATION	TYPE OF APPENDICITIS		
	UNRUPTURED	PERFORATED	ABSCESS
48 hours or less	4	8	1
49 to 72 hours	4	11	-
73 to 96 hours	3	15	2
More than 4 days	2	19	11
Total	13	53	14

In Table VIII is shown the extent to which the hospital must assume responsibility for delay in operation. It is indeed striking that 58 patients, nearly 3 out of 4, were operated upon within six hours of reaching the hospital; this clearly points the lesson that speed in getting the patient to the operating room will of itself not save these lives. The fatal delay in these patients must be assumed to have taken place before they reached the hospital.

TABLE VIII. ANALYSIS OF DEATHS FROM APPENDICITIS—HOSPITAL DELAY IN OPERATION

No delay (operation within 6 hours)		58
Delay more than 6 hours		22
Refusal of patient	2	
Diagnosis uncertain	16	(6 longer than 24 hours)
Diagnosis certain, therapeutic	4	(all longer than 24 hours)

Occasionally patients will die even if operated upon promptly after the onset of symptoms, but they do not reach impressive numbers. Only 6 patients in the present series died after an operation performed within thirty hours of the first symptom, less than 8 per cent of the fatal cases; details are given in Table IX. It is significant that 5 had received catharties, that perforation had already taken place within the thirty hours in 5, and that 3 had a fulminating infection. All of the patients were 45 years of age, or older. All of the cases occurred before chemotherapy was available. Perhaps the sulfonamides would have saved some of them.

TABLE IX. ANALYSIS OF DEATHS FROM APPENDICITIS—OPERATION WITHIN THIRTY HOURS OF FIRST SYMPTOM

YEAR	AGE	SEX	TYPE OF APPENDICITIS	LOCATION	CATHARTIC	TOTAL SURVIVAL (DAYS)	COMMENT
1913	47	M	Perforated	Iliac fossa	Yes	11	Multiple abscesses
1925	45	M	Unruptured	Pelvis	Yes	4	Fulminating course
1929	67	F	Perforated	Iliac fossa	Yes	13	Marked ileus
1932	47	M	Perforated	Retrocecal	Yes	2	Fulminating course and massive pulmonary atelectasis
1936	49	M	Perforated	Pelvis	?No	10	280 lb. severe diabetic; multiple abscesses
1938	57	M	Perforated	Retro-ileal	Yes	6	Fulminating course

TABLE X. ANALYSIS OF DEATHS FROM APPENDICITIS—UNCERTAIN OR INCORRECT PREOPERATIVE DIAGNOSIS*

PRESUMPTIVE DIAGNOSIS	NUMBER CASES	OPERATIVE DELAY		
		NONE	7-24 HR.	25 HR. +
Intestinal obstruction	6	2	4†	–
General peritonitis, unknown cause	3	1	1	1
Renal disease (?)	3	1	–	2
Biliary tract disease (?)	3	1	2	–
Gynecologic disease (?)	2	–	1	1
Perforated peptic ulcer	1	1	–	–
"Medical disease"				
Typhoid	1	–	–	1
Pneumonia	1	–	1	–
"Appendicitis unlikely"	3	–	2	1
Total	23	6	11	6

*23 cases: 3 unruptured, 14 perforated, 6 abscess.
†One patient refused operation temporarily.

As far as hospital delay is concerned, the most challenging problem is presented by the patient whose operation is postponed because of uncertain diagnosis. In Table X are particularized the fatal cases which presented initial diagnostic difficulties (although in 6 instances it did not result in appreciable delay). There is little to add since the protean manifestations of acute appendicitis are widely appreciated. One must weigh in each individual the disadvantage of delay in a possible appendicitis against the advantage of not operating upon a patient critically ill with coronary thrombosis, pneumonia, or nephritis. Cases in which the patients have been spared operation by judicious observation are not tabulated in this paper, nor is it easy to find these records in hospital archives. It is worth noting, however, that of the 23 patients who were diagnostic problems, in only 8 were conditions suspected in which abdominal exploration would be contraindicated, that is, renal disease, "appendicitis unlikely," and "medical" disease. Earlier operation as a step in diagnosis should be considered when the differential lies between appendicitis and such conditions as intestinal obstruction or acute salpingitis, utilizing, if necessary, two incisions (exploring the appendix first) in order to avoid tragic delay.

Operative Procedure.—In Table XI is shown the operative procedure which was carried out in the 80 cases. The conclusion one reaches is that some patients will die irrespective of the procedure carried out. Except for the localized abscesses there will be few occasions when appendectomy cannot be carried out. On these grounds one may question the circumstances in which a simple incision and drainage was the only procedure done in 6 patients with free perforation. Actually, however, in 3 cases appendectomy was not carried out because the appendix could not be readily found and was presumably so necrotic that it was no longer recognizable; in 1 case operation was carried out through an upper abdominal incision under the mistaken diagnosis of acute cholecystitis, and the correct diagnosis was found only at post-mortem; in the other two instances surgeons of experience operating upon desperately ill pa-

TABLE XI. ANALYSIS OF DEATHS FROM APPENDICITIS—OPERATIVE PROCEDURE

TYPE OF APPENDICITIS	APPENDECTOMY			INCISION AND DRAINAGE	
	NO DRAINS	DRAINS	ENTEROSTOMY	SIMPLE	ENTEROSTOMY
Unruptured	2	11	–	–	–
Perforated	1	41	3	6	2
Abscess	–	7	–	7	–
Total	3	59	3	13	2

tients contented themselves with the simplest operative procedure and perhaps avoided a fatality on the operating table thereby.

A cross-analysis of the location of the appendix with reference to the type of incision is given in Table XII. Four patients with pelvic appendicitis were operated upon through a McBurney incision; 15 patients with retrocecal appendicitis had right rectus incisions. Although a reversal of these incisions might have been more suitable, only one-quarter of the patients is involved, and it is obviously not a matter of first magnitude. Furthermore, the disagreement existing between surgeons of wide experience is evidence that the choice of incisions is not of fundamental importance. In this clinic we happen to incline to the McBurney incision as the one of preference in all instances except pelvic appendicitis or in diagnostic problems in women. To revert to first principles, however, one may say that the proper incision in any given case is the one which will give the surgeon the best access to the appendix with the least disturbance to the remainder of the peritoneal cavity. As in one case in the present series, such an incision may occasionally be in the left upper quadrant (where the undiagnosed appendicitis lay).

TABLE XII. ANALYSIS OF DEATHS FROM APPENDICITIS—LOCATION OF APPENDIX RELATED TO OPERATIVE INCISION

LOCATION	NUMBER CASES	INCISION			
		RIGHT RECTUS	MC BURNEY	MIDLINE	OTHER
Iliac fossa	35	22	7	6	–
Retrocecal	22	15	6	–	1*
Pelvis	18	12	4	2	–
Retro-ileal	2	1	1	–	–
Subhepatic	1	–	–	1	–
Left upper quadrant	1	–	–	–	1†
Not specified	1	1	–	–	–
Total	80	51	18	9	2

*Right upper rectus incision for supposed acute cholecystitis.
†Left upper rectus incision.

It would be foolish indeed to underestimate the importance of what the surgeon did and how he did it in sizing up the outcome in a particular case of acute appendicitis. Only rarely is it possible to surmise from the operative notes themselves that an improper operation has been performed. In one fatal case the surgeon took nearly two hours to carry out a painstakingly thorough exploration of the entire abdomen in a critically ill patient with a perforated appendicitis before finding and removing the offending organ. This death must surely be blamed upon the surgeon. In the overwhelming majority of instances, however, the operative note does not indicate the presence or absence of those intangible but all-important factors of gentleness, skill, and good judgment. In this series with an average of only four or five deaths a year it is impossible to incriminate individual surgeons on statistical grounds, for one surgeon might be unfortunate enough to operate upon a succession of patients whom the most skillful surgery could not save. It is necessary, therefore, to adopt statistical methods in order to pool the experience of the entire hospital staff. A further analysis of the role of the type of incision and the use of drains will be dealt with statistically in the second part of this paper.

Fatal Acute Unruptured Appendicitis.—Thirteen patients who died of progressive appendicitis had neither a perforation nor a localized abscess at the time of operation. It was pointed out earlier in this paper, however, that the system employed in grouping cases does not preclude a serious infection al-

ready existing beyond the appendix although it has not grossly perforated. In Table XIII this point is demonstrated by showing that the peritoneal culture was positive in the six instances when it was taken. Nine patients were known to receive cathartics. That drainage of the peritoneal cavity will not save these patients is proved by the fact that drainage was carried out in 11. Perhaps it is significant that there has been no fatal case in this group since 1933; chemotherapy might well have turned the scales in some.

TABLE XIII. ANALYSIS OF DEATHS FROM APPENDICITIS—ACUTE UNRUPTURED APPENDICITIS*

Entered hospital 48 hours or more after onset	9
Received cathartic	9
Operative delay from incorrect diagnosis	1
Drained at operation	11
Age under 15	5
Age over 50	4
Peritoneal culture	
Positive	6
Negative	0
Not taken	7
"Unavoidable" deaths	
Pylephlebitis	2
Congestive heart failure	1
Pulmonary tuberculosis	1
Anesthetic death, 2nd operation	1

*13 cases (none since 1933).

Chemotherapeutic Failures.—Although the sulfonamide drugs have been unanimously received as welcome and potent new weapons in the treatment of acute appendicitis, some of the earlier reports of their use have been somewhat overoptimistic. In Table II (previously referred to) are listed details concerning 3 patients who died although they had received what is generally regarded as adequate dosage of one of the sulfonamides. One of the three was given intraperitoneal drug as well. Several additional fatal cases where chemotherapy was employed late or in insufficient dosage have not been included. These cases are cited as a reminder that the "wonder drugs" are not invariably effective. The existence of a promising new therapeutic weapon must not blind us to the importance of the many other factors involved in the proper care of a patient with acute appendicitis: a well-timed and properly executed operation; effective decompression of the gastrointestinal tract; maintenance of nutrition with blood and plasma transfusions. When these other features can be forgotten, acute appendicitis will properly cease to be a surgical problem and can be treated by anyone who can follow a dosage schedule.

Extra-abdominal Disease, Preoperative and Postoperative.—Fourteen of the 80 patients had a serious constitutional disease antedating the acute appendicitis; 6 had diabetes, 6 had heart disease (3 developing congestive failure), 1 had chronic nephritis, and 1 had pulmonary tuberculosis. Thirty patients developed a postoperative pulmonary complication; the various types are listed in Table XIV. The nine instances in which it was felt that the extra-abdominal disease played an important contributory role in the fatal issue have already been referred to. In the remainder, although additional disease is always unwelcome, either the severity of the appendicitis was such as to overshadow anything else, or the disease was sufficiently controlled (as in mild diabetes) to be considered relatively unimportant.

Miscellaneous Data.—Table XV lists various facts which are of general interest. This emphasizes the preponderance of men, the large proportion of patients entering the hospital forty-eight hours or more after the onset of symp-

TABLE XIV. ANALYSIS OF DEATHS FROM APPENDICITIS—POSTOPERATIVE PULMONARY COMPLICATIONS*

Atelectasis	7
Bronchopneumonia	6
Pleurisy	3
Lobar pneumonia	2
Massive atelectasis	1
Empyema	1
Metastatic abscesses	1
Terminal bronchopneumonia	9
Total	30

*30 of 80 cases: 38 per cent.

TABLE XV. ANALYSIS OF DEATHS FROM APPENDICITIS—MISCELLANEOUS DATA, EIGHTY ABDOMINAL DEATHS

Entered hospital 48 hours or more after onset	67
Received a cathartic	49
Operation delayed more than 6 hours for diagnosis	16
Admission pulse	
100 or more	62
120 or more	22
Duration of operation	
One hour or less	61
More than 1½ hours	3
Peritoneal culture	
Positive	45
Negative	5
Not taken	30
Sex	
Males	54
Females	26
Age	
Over 50 years	24
Over 70 years	8

toms, the frequency with which cathartics had been taken, and the high proportion of positive peritoneal cultures.

MORTALITY STATISTICS BASED UPON ABDOMINAL CAUSES OF DEATH

We are utilizing the concept of extra-abdominal and abdominal causes of death in deriving a new series of mortality statistics which excludes those patients dying from extra-abdominal causes. The 18 cases listed in Table V have been "thrown out" from the statistics which follow just as if the patients had never entered the hospital. It has seemed fair to assume that the operative management of these 18 cases could not be blamed for the fatal result, since in each instance, as far as could be determined, the appendicitis was fully checked, improving, or (in 1 or 2 cases) healed. On the other hand, it is highly unreasonable to regard these patients as successfully treated. Hence their rigid exclusion. The 5 patients who died without operation, and the patient who died following an operation in another hospital and the two anesthetic deaths are likewise excluded.

The following statistics, then, are based upon every case of acute appendicitis in which the patient was treated by operation in the Peter Bent Brigham Hospital in the years 1913 through 1940, with the exceptions just given. Every case in the 2,175 under consideration had pathologic verification of the diagnosis except in those rare instances when the appendix was not removed; in such cases the operative diagnosis was beyond reasonable doubt. The criteria for classifying cases as unruptured, perforated, and abscess have already been explained and have been rigidly followed, in the successfully treated patients as well as the fatal cases. The importance of pathologic control and strict

criteria for grouping cannot be overemphasized if statistics are to be of value. The possible consequences of loosely applied criteria are suggested in this hypothetical series.*

TABLE XVI. ANALYSIS OF DEATHS FROM APPENDICITIS—MORTALITY RATE BY FIVE-YEAR PERIODS BASED UPON ABDOMINAL DEATHS

YEARS	TOTAL CASES	DEATHS	MORTALITY (%)
1913-1920	473	24	5.1
1921-1925	417	12	2.9
1926-1930	403	13	3.2
1931-1935	373	15	4.0
1936-1940	509	16	3.1
1913-1940	2,175	80	3.7

General Mortality Rates.—In Table XVI are given the mortality figures in abdominal causes of death by five-year periods (compare with Table I). It can be seen that even with this new concept there has been no significant improvement in twenty years. In Table XVII these figures are further broken down into the three great groups of appendicitis; once again no improvement of any

TABLE XVII. ANALYSIS OF DEATHS FROM APPENDICITIS—MORTALITY RATE BY FIVE-YEAR PERIODS BASED UPON ABDOMINAL DEATHS

	ACUTE UNRUPTURED APPENDICITIS		ACUTE PERFORATED APPENDICITIS		APPENDICAL ABSCESS	
YEARS	CASES	MORTALITY (%)	CASES	MORTALITY (%)	CASES	MORTALITY (%)
1913-1920	294	1.4	97	17.5	82	3.7
1921-1925	315	0.3	52	17.3	50	4.0
1926-1930	305	1.3	56	12.5	42	4.8
1931-1935	283	1.4	50	14.0	40	10.0
1936-1940	402	0.3	78	15.4	29	10.4
1913-1940	1,599	0.9	333	15.6	243	5.8

significance can be shown.† In effect, these tables say that despite improved technique in the operating room, in spite of better understanding of gastrointestinal physiology and the role of gastrointestinal siphonage, in spite of closer attention to fluid balance and nutrition, we are not saving any more patients today than we did twenty years ago.

Relation of Type of Incision and Mortality.—In Table XVIII the incision employed is cross-analyzed with respect to the type of appendicitis, and the

*Let us assume a hypothetical series:

Acute unruptured appendicitis			Acute perforated appendicitis		
Cases	Deaths	Mortality	Cases	Deaths	Mortality
1,000	10	1%	200	30	15%

Now let us suppose that we do not use microscopic verification for our diagnosis of acute appendicitis, and add 100 cases of "clinical" acute appendicitis where the operator has, for one reason or another, called a normal appendix "acute." (This will happen occasionally to the best and most conscientious surgeons, and frequently to poor ones.) In none of these 100 new "acute" cases is the patient likely to have died. Now let us transfer over to the perforated group 100 cases from the acute unruptured group; let us say these were severe cases with a gangrenous appendix, many with a cloudy peritoneal fluid and perhaps evidence of a generalized peritonitis (perhaps even a positive culture), fitting a loose grouping of "perforated" appendicitis; let us say that in three of this transferred group the patient died. The following figures result:

Acute unruptured appendicitis			Acute perforated appendicitis		
Cases	Deaths	Mortality	Cases	Deaths	Mortality
1,000	7	0.7%	300	33	11%

The mortality figures in both groups have undergone a definite improvement. It is probably a safe guess that at least some of the very favorable figures appearing in the literature are a result of unconscious "padding" such as this. Deaths cannot be wished away, but the groups in which they fall can be so swelled that mortality rates are misleading.

†The following formula has been used for determining a significant difference between mortality rates in two series:

Series 1		Series 2	
No. of cases	Mortality	No. of cases	Mortality
X	A%	Y	B%

Suppose A greater than B, the difference is then A-B. This difference is significant if

$$\frac{A - B}{\sqrt{\frac{A \times (100 - A)}{X} \text{ plus } \frac{B \times (100 - B)}{Y}}}$$ is greater than 2.

TABLE XVIII. ANALYSIS OF DEATHS FROM APPENDICITIS—COMPARISON OF INCISION AND MORTALITY (BASED UPON ABDOMINAL DEATHS)

TYPE OF APPENDICITIS	MC BURNEY INCISION			OTHER INCISIONS (R. RECTUS, MIDLINE, ETC.)		
	CASES	DEATHS	MORTALITY (%)	CASES	DEATHS	MORTALITY (%)
Unruptured	654	2	0.3	945	11	1.2*
Perforated	93	10	10.8	240	43	17.9
Abscess	78	5	6.4	162	9	5.6

*There is a significant difference between 0.3 and 1.2 per cent.

mortality rate. The McBurney incision is contrasted with all other types (all but a very few of the others being right rectus or midline). The table shows results consistent with earlier comments in this paper: no overwhelming advantage is shown for the McBurney incision. In acute unruptured appendicitis there is a definite edge and in acute perforated appendicitis there is an apparent edge in favor of the McBurney; in appendical abscess there is an apparent slight edge against the McBurney. These differences are not striking for the size of the series involved.

If, however, the acute unruptured appendicitis cases are lumped with the perforated ones (Table XIX) there is a significant statistical advantage shown for the McBurney incision. It is reasonable to place them together and consider abscess separately, because usually appendical abscess can be diagnosed beforehand and an incision accurately placed over it for drainage. In the other two groups, which are not infrequently confused preoperatively, localization is less accurate and the operative problem is identical: to remove the appendix with the least possible disturbance of the rest of the peritoneal cavity.

TABLE XIX. ANALYSIS OF DEATHS FROM APPENDICITIS—COMPARISON OF INCISION AND MORTALITY (BASED UPON ABDOMINAL DEATHS)

	MC BURNEY INCISION			OTHER INCISIONS (R. RECTUS, MIDLINE, ETC.)		
	CASES	DEATHS	MORTALITY (%)	CASES	DEATHS	MORTALITY (%)
Combined groups of unruptured and perforated appendicitis	747	12	1.6	1,185	54	4.6*

*There is a significant difference between 1.6 and 4.6 per cent.

Relation of Drains and Mortality.—Table XX portrays the effect of both drainage and incision in acute unruptured appendicitis. One interesting fact is brought out: if one decides to place a drain in a patient with acute unruptured appendicitis (a maneuver which we now deplore) there is no significant increase in the mortality rate if the McBurney incision is used; in other types of incision there is a significant increase in mortality with drainage. This is a reasonable findng when one reflects that a medially placed drain can produce

TABLE XX. ANALYSIS OF DEATHS FROM APPENDICITIS—COMPARISON OF DRAINS AND INCISION IN ACUTE UNRUPTURED APPENDICITIS*

	MC BURNEY INCISION			OTHER INCISIONS (R. RECTUS, MIDLINE, ETC.)		
	CASES	DEATHS	MORTALITY (%)	CASES	DEATHS	MORTALITY (%)
Drained	88	1	1.1	266	10	3.7†
Not drained	566	1	0.2	679	1	0.1
Total	654	2	0.3	945	11	1.2

*Based upon abdominal deaths.
†There is a significant difference between 3.7 and 0.1 per cent.

TABLE XXI. ANALYSIS OF DEATHS FROM APPENDICITIS—COMPARISON OF MORTALITY IN DRAINED AND UNDRAINED CASES*

TYPE OF APPENDICITIS	DRAINED†			NOT DRAINED		
	CASES	DEATHS	MORTALITY (%)	CASES	DEATHS	MORTALITY (%)
Unruptured	354	11	3.1	1,245	2	0.2
Perforated	291	52	17.8	42	1	2.4

*Based upon abdominal deaths.
†The greater mortality in the cases in which drainage was done is statistically significant.

more dissemination of infection in the peritoneal cavity than one placed laterally. One assumes that the two cases in which drainage is carried out are of comparable severity.

This vexing problem of when to drain is further dealt with statistically in Table XXI. The lesson in these figures does *not* lie in the fact that more patients die in whom drainage was carried out, than do those in whom drainage was not done; it is always argued, correctly, that the worst cases are the patients in whom drains are usually employed, and it is no surprise to see a greatly increased mortality rate in those drained. What is worthy of note is the low mortality rate in the perforated group closed without drainage; it proves that patients properly selected do not require drains in order to get well. This group of perforations (presumably the ones with least soiling of the peritoneal cavity and the best risk patients) may be considered roughly comparable to the worst group of unruptured appendicitis (those presumably drained). If perforated cases can be so well selected that the mortality rate stays below 3 per cent, the implication is inescapable that there will be practically no cases in the unruptured group which will require an intra-abdominal drain. The figures naturally do not prove that the drain was responsible for death when used in unruptured appendicitis, but at least they show that the drain failed to prevent death.

The trend toward tight closure in unruptured appendicitis is shown in Table XXII; when this is contrasted with the essentially unchanging general

TABLE XXII. ANALYSIS OF DEATHS FROM APPENDICITIS—MORTALITY AND DRAINAGE BY FIVE-YEAR PERIODS IN ACUTE UNRUPTURED APPENDICITIS*

YEARS	CASES	PER CENT DRAINED	MORTALITY (%)
1913-1920	294	42.5	1.4
1921-1925	315	36.5	0.3
1926-1930	305	15.7	1.3
1931-1935	283	17.2	1.4
1936-1940	402	4.9	0.3

*Based upon abdominal deaths.

mortality rate over the years for this same group it can be seen that this policy has not affected the mortality adversely.

SUMMARY AND CONCLUSIONS

The failure of improvement in mortality figures for patients with acute appendicitis treated at the Peter Bent Brigham Hospital from 1913 through 1940 has stimulated a detailed study of the 106 fatalities occurring during this period. Emphasis is placed upon the importance of pathologic examination of the appendix in obtaining accurate statistics, and criteria are given for grouping cases as acute unruptured appendicitis, acute perforated appendicitis, and appendical abscess. Attention has been focused upon the 80 operative cases in which death of the patient was directly attributable to progressing appendicitis or its specific complications.

Delay in operation is shown to be a major factor in fatal cases. Sixty-seven of the 80 patients were operated upon forty-eight hours or more after the initial symptom. Fifty-eight patients were operated upon within six hours of reaching the hospital, but hospital delay of more than six hours because of an uncertain diagnosis took place in 16 cases. It is suggested that there be prompt operation when the differential diagnosis lies between acute appendicitis and some other condition such as acute salpingitis in which operation is not definitely contraindicated. The consequences of delay (whatever the reasons may be) are reflected in the fact that at the time of operation 53 patients had acute perforated appendicitis, 14 had appendical abscess, and only 13 had acute unruptured appendicitis. There were only 6 fatalities in patients operated upon within thirty hours of onset; of these, 5 had perforated appendicitis. It is likewise worthy of mention that 49 of 80 patients definitely received cathartics.

Fifteen patients had undrained residual abscesses at the time of death. Such abscesses should be specially sought for in patients not improving after two weeks from the onset of the disease. Ten patients died of severe ileus or mechanical intestinal obstruction; prompt preventive measures, or well-timed operative intervention might have saved some of them. Three patients died despite "adequate" dosage with sulfonamides; they are cited as proof that the management of acute appendicitis is complex and has not been solved by chemotherapy.

Statistics based upon the 80 cases give a slight advantage for the McBurney incision. Statistics likewise vindicate the trend in recent years toward closure without drainage, including selected cases with perforation.

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TECHNIQUE AND RESULTS OF PRIMARY AND SECONDARY PULL-THROUGH OPERATION AFTER REMOVAL OF TUMORS OF THE RECTUM AND RECTOSIGMOID

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DURING the past twenty-two years, I have devoted much attention and energy to the study of the problems of rectal surgery. At Hochenegg's clinic in Vienna I was entrusted with the follow-up examinations of over 1,000 rectal operations and I have had the opportunity of performing many hundreds of rectal operations myself. I have reported in many publications my experience dealing with rectal carcinoma, its operative treatment, and operative prospects and results.

Two major principles stand out clearly if one views the matter under the aspect of the future development of rectosigmoid surgery.

Anyone interested in the surgical approach to carcinoma of the rectosigmoid, which yields the best operative end results of all types of carcinoma amenable to surgical measures, should be familiar with any typical operation devised for this purpose; he should carefully make his plan and weigh the chances with due consideration of the individuality of the case as well as the site and spread of the tumor.

The technical methods most commonly practiced are: (1) The radical dorsal operation (Lockhart-Mummery), (2) rectal extirpation by the extended sacral method developed on the basis of that devised by Kraske and Hochenegg (Mandl-Goetze), and (3) the one-or multiple-stage abdominodorsal operation (preference to be given to the one-stage method [Miles]).

In the treatment of anal carcinoma which is an especially malignant tumor usually, it is often necessary to resort to electrosurgery, a detailed and comprehensive study of which has recently been published by Roffo and Carranca. It would exceed the extent of this article to discuss the pros and cons of all methods, particularly as they are sufficiently known.

Any method sacrificing the sphincter ani where it might be preserved without endangering the radicality of the operation must be considered an imperfect one. The progress of rectal surgery is marked by the now possible combination of a very high degree of radicality with preservation of the sphincter, that is, restoration of continence.

Viewing the matter from a psychologic viewpoint, it should be borne in mind that patients may find colostomy very compatible with business and their other duties. They usually adjust their habits and diet to the situation according to their own experience, and achieve quite satisfactory control over bowel movements, which may naturally be still further improved by various devices. The great majority, however, of all those suffering from incontinence or, even more so, those with an artificial anus, whether abdominal or dorsal, easily fall a prey to depression, are barred from any kind of social activity and, for the greatest part, are incapacitated. It is common knowledge that patients who may not even fear recurrences commit suicide for the simple reason that life has become unbearable with an artificial anus. This is even more likely to

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occur if they are in an unfortunate financial position or particularly hampered in their professional career. I have, therefore, adopted it as an unshakable axiom that radical operation for rectal carcinoma, even if performed with the greatest possible degree of technical skill and even if the results are permanent, is imperfect unless an attempt has been made to preserve continence or, at least, to give the patient the well-founded hope, with a clear conscience, of its future restoration. The foolish sacrifice of sphincters is barbaric and everything should be done to substitute these methods by others guaranteeing the preservation of the sphincter.

There can be no doubt that the maintenance of sphincteric function involves greater risks both for the patient and for the surgeon than does simple radical operation. Aftertreatment is, moreover, more inconvenient and the prolonged stay in the hospital must be followed by weeks or even months of ambulant treatment.

There is no denying that preservation of the sphincter may occasionally be impossible. If, for example, the tumor, of whatever type it may be, is itself imbedded in the sphincteric or anal portion, the radicality of the operation would greatly suffer by any attempt to proceed conservatively—a risk that cannot be taken. In approximately 25 per cent of all cases of rectal carcinoma the idea of preserving sphincteric function must be abandoned from the outset. Here the establishment of a sacral anus, at as low a level as possible, ensures relative continence provided there is adequate scar shrinking and control by innervation of the gluteal musculature, an aim that can also be attained by the "gluteal anus" as devised by Petermann.

The preservation of sphincteric function in malignancy of the rectosigmoid has, up to quite recently, received little attention in the Anglo-American literature. Earlier suggestions referring to that point (Maunsell, 1892, Weir, 1901) were recently reviewed by Wangensteen, but it seems that this has not aroused much attention either.

The discussion was recently reopened by Babcock and Bacon, who advocated preservation of the sphincter if the tumor is within at least 7 cm. from the sphincter ani. Wangensteen (1943) critically scrutinizing the problem, believed that methods for the full restoration of sphincteric function might very well be worked out, and that "re-study of the Kraske-Hochenegg sacroperineal methods with special attention to an abdominal method . . . . with preservation of the sphincter is in order." He referred to two papers (Wilensky, 1942, and Pannett, 1943) dealing with the preservation of the sphincter in abdominoperineal operations, the originals of which are, however, unfortunately not accessible to me. Finally, the Agenda of the Ninth National Assembly of the International College of Surgeons, in Philadelphia, 1944, announced that Bacon and co-workers would report on "Surgical Treatment of Rectal and Sigmoid Cancer Without Colostomy With Sphincter Muscle Preservation" and A. A. Berg on "The Preservation of Sphincter Ani in Radical Operation for Cancer of the Rectum." In his book, moreover, Bacon refered to the pull-through method, adding a brief description.

As far as we know, the French literature does not contain many contributions to the question of the preservation of sphincters (see Bergeret). Cuneo, Seneque, and Zagdoun practiced the method of circular suture of the rectum after "perineal resection" with preservation of sphincters. Years ago I attended the excellent performance of the pull-through operation by Hartmann and Victor Pauchet.

In the German literature, methods advocating the preservation of continence are fairly numerous: (1) by circular suture (Kraske) after resection of the tumor from its continuity within the sacral wound and (2) by the pull-through method devised by Hochenegg, while (3) Hochenegg's "invagination method" has scarcely been practiced.

It is of particular importance to bear in mind, provided the tumor lies at an adequate distance from the anus with no involvement of the sphincteric portion itself, that the preservation of the sphincter has by no means an unfavorable influence on the ultimate result of the operation—a point constantly stressed by me after conscientious study of 1,300 cases with inclusion of the entire literature. I have emphasized this point in numerous publications and the opinions of only a few other authors which could not be taken into consideration on these earlier occasions remain to be added.

Goepel described a two-stage abdominosacral method, the second stage terminating in the pull-through act (Hochenegg). In one of his cases, exterioration through the anus of a length of 7 to 8 cm. of the large intestine could be performed without gangrene supervening.

H. Kraske paid special attention to the preservation of the sphincter. If the intestinal portions at one's disposal are short, a circular suture is made in the dorsal wound while the normal procedure is the pull-through method. Where the sphincteric portion must be sacrificed, the distal end of the rectum is used for the construction of a gluteal anus. Full continence was reported by this author in 50 per cent.

Petermann, the inventor of the gluteal anus, also advocated preservation of the sphincter wherever possible. He gave preference to the pull-through method and reported continence in 50 per cent of his cases.

Nordmann also maintained that in the absence of sphincteric involvement all available means should be mobilized to preserve sphincters (1) by employing the method devised by Kuettner with sacral exterioration and subsequent amputation of the tumor with secondary suture or (2) by the pull-through method (Hochenegg) without distention of the sphincter or excision of mucous membrane. He pointed out that healing of "circular sutures" after primary resection of the wound was very rare.

Dannhaeuser, in connection with the dorsal as well as with the combined method, laid particular stress on the preservation of the sphincter and with the customary methods he reported satisfactory results in 77 per cent of cases.

Hybinette of Stockholm, sacrificed the anal portion only if the site of the carcinoma was a very low one. For those situated higher up, he recommended as the method of choice the abdominodorsal approach, pulling the colon down through the anus. He prefered this method to circular suture.

From the foregoing it appears that no surgeon earnestly concerned with the preservation of sphincteric function deems the methods advocated by him for this purpose a danger to the radicality of the operation for carcinoma of the rectum or sigmoid.

A great step forward in this respect was marked recently by the microscopic studies published by Westhues. This author pointed out that: (1) Carcinomatous metastases, whether in connective tissue or in lymph nodes, which are on the level of the carcinoma itself or higher up are, for all practical purposes, confined to the neighborhood of the superior hemorrhoidal artery. (2) Beyond the level of the tumor itself, no involvement of the intestine and especially

the pericolic connective and lymphatic tissue takes place. This was, in some measure, verified by R. S. Grinnell who pointed out that "the main extramural lymph spread is upward along the superior hemorrhoidal vessel." For no more than one out of seventy-five specimens which were carefully studied could Grinnell report downward spread.

Seefeld and Bargen, after reviewing 100 cases of rectal carcinoma, maintained that the significance of metastases of this type of carcinoma to veins and nerves was practically as great as that to the lymph drainage area (47:20:30). This fact, however, does not alter our attitude toward the problem of rectal carcinoma. Our practical approach to the question has thus received what one might call theoretic support which is today generally acknowledged.

The preservation of the sphincteric portion by no means always implies restoration of continence. There is no doubt that with the methods so far at our disposal it is in but a limited percentage of cases that we may succeed in doing so. My personal experience, as well as the literature referring to that point, proves thus far that the safest way to ensure continence is by the pull-through method devised by Hochenegg in 1888, which is also to be preferred to Kraske's method consisting in circular suture after resection of the carcinoma by the dorsal approach. This is also clear from an anatomic viewpoint, as a circular suture between two portions of intestine can be approximated only if both parts are well covered with serosa.

This "circular suture" within the wound, as a rule, implies the union of one serosa-bearing part (the proximal extremity of the mobilized sigmoids) and one with no serosal covering (the peripheral extremity of the rectum at the level of the ampulla or sphincter). In view of what we know about intestinal sutures in general since the time of Lembert and Jobert (1824 and 1826, respectively), no smooth healing can be expected under these circumstances.

This is also the drawback of a method recently introduced by Dixon, Dunphy, and associates, the so-called "anterior resection." Apart from the viewpoint of radicality and blood supply, the removal of recto-sigmoid carcinoma from below the Douglas pouch by pushing the tumor into the abdominal cavity makes it questionable whether the peripheral portion of the intestine is still covered by serosa. Otherwise the procedure is certainly doomed to failure.

It would be of interest to know in what percentage of cases continence can be restored after preservation of the sphincter. According to my personal experience, healing by first intention occurs in but 20 per cent of cases after Kraske's circular suture. By an additional operation one may improve the operative results up to from 40 to 50 per cent, while in the others fistulas are likely to form, which confront the patient as well as the attending physician with the tedious task of a prolonged and inconvenient aftertreatment.

Regarding Hochenegg's pull-through method, it should above all be pointed out that even after preservation of the sphincter it can only be employed in a certain percentage of cases and under very strict provisions. This percentage may amount to from 30 to 40 per cent of all those cases in which the sphincter has not been sacrificed. According to my studies in 1929, primary restoration of continence was possible in 60 per cent. After an additional operation, positive results could be increased to 65 per cent, and although this is a relatively small percentage it is, nevertheless, worth trying.

In the following, the technique of the so-called "primary pull-through method" of Hochenegg is described and suggestions are made as to how, according to my personal experience, to bring it to a successful termination, since

nowhere in the literature has the method been dealt with in detail. I am also giving a description of the so-called "secondary pull-through method" which may allow a greater number of patients to have continence restored.

PRINCIPLES

I. The Primary Pull-Through Operation

A. Radical Operation.—There can be no doubt that with the combined abdominosacral or abdominodorsal and also by the purely dorsal method (sacral, extended sacral method, Mandl-Goetze) as much of the colon can be mobilized as is necessary to perform the pull-through through the intact sphincter. At the European clinic where I formerly worked, I employed this method in several cases after combined abdominosacral operation (see Case 1), while here in this country I have had only one such case.

B. Precondition.—A precondition for the smooth healing after pull-through operation is the preliminary construction of colostomy. In the past few years I have preferred the method of establishing preliminary colostomy in the transverse colon approximately a fortnight prior to radical operation. Only strict avoidance of contamination to the dorsal wound, where the operation for restoration of continence takes place, ensures success. That the pull-through operation was successful in a few exceptional cases in spite of no preliminary colostomy being made is of no importance. When colostomy is performed, the abdominal organs should be inspected (length of sigmoids, width of mesosigmoids).

C. The Sequence of the Various Manipulations in Radical Operation.—It may be concluded from publications and suggestions in the literature that it is worth while to point out that the pull-through manipulation should follow as the last in the sequence of events for the following reasons: Only after radical operation has been completed is it possible (1) to form an opinion on the nutritional condition of the peripheral intestinal portion, (2) to ascertain whether the length of the intestine will suffice to undertake the pull-through, and (3) for reasons of asepsis (see *D*).

D. The Technique of the Primary Pull-Through Operation.—After abdominal mobilization and ligature of blood vessels, whether in a typical or atypical way, *or* after mobilization of the colon by the sacral approach, extensive portions of the tumor are exposed in the sacral wound. Shortly before closing the wound the surgeon must decide whether to proceed to the pull-through operation. The best guarantee for the success of this part of the operation is a well-developed vascular supply to the part which is to be pulled through, the most important criterion for which is the color of the bowel after mobilization. Today we know for certain, as a result of numerous studies (the latest publication on that point probably being that by Singleton), that it is at the site of ligature (Sudeck's "critical point") that the last full anastomosis between the superior hemorrhoidal and the inferior mesenteric arteries by way of the sigmoidal artery can be expected and it is often, although not invariably, possible to take this into consideration when making the plan for the operation. However, in the majority of cases, practical considerations demand grossly anatomic mobilization up to a degree until as much of a well-supplied bowel is at our disposal as is necessary to be pulled through the sphincter. As a general rule, exceptional width of the mesosigmoid already suggests that a sufficient length of sigmoid will be available for the further procedures. Roentgenologic studies prior to operation or inspection of the parts exposed during colostomy will give a helpful idea on the length of the sigmoid.

Apart from the color of the bowel wall, inspection of the small, subserous blood vessels of the portion used for the pull-through is a valuable aid. Pulsation can be visualized by painting with a 6 per cent phenol solution.

To avoid failures, no efforts should be spared to make certain that the bowel used for the pull-through is actually of normal vitality. It should, therefore, be carefully covered with warm cloths and watched for the appearance of any color change, as it is routine, for example, in operations for incarcerated hernia.

1. *To ensure the vitality of the bowel,* the care of the wound through which it passes is of great importance. It is imperative that within the sacral wound the intubated intestinal segments be approximated by interrupted sutures (Fig. 1) and the bowel, as far as possible, be covered by soft parts. This provides the best protection, for the serosa does not tolerate well contact with strips of gauze. The secretion should be aspirated by rubber drains. Spraying with sulfanilamide, according to our latest experience, apparently does not reduce the vitality of the bowel and is further a valuable help in keeping the wound cavity clean.

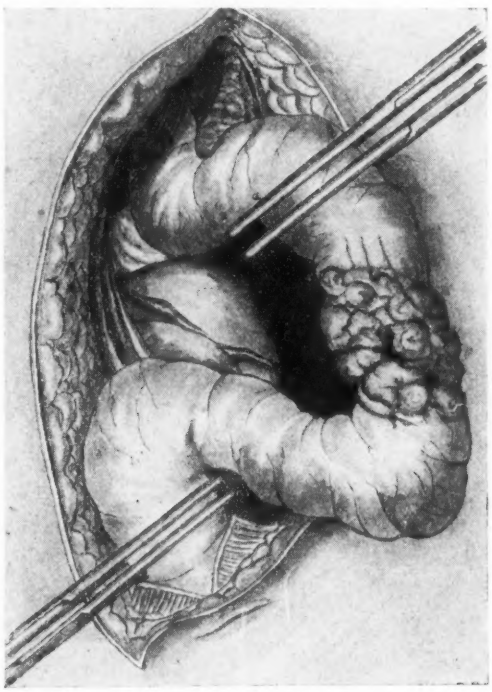

Fig. 1.—Modification of picture given by Bacon. The tumor together with the rectosigmoid has been mobilized by posterior approach or by abdominodorsal method. The Douglas sac has not yet been closed. After its closure and after further mobilization an attempt will be made to approximate segment *a–b* (after resection of the tumor between the clamps) to *a′–b′*. If this is possible without tension and the blood supply remains normal, the "pull-through" may be envisaged.

2. *How is the sphincteric portion attended to?* Manipulations on the sphincteric portion should not be started before the operation on the proximal part is completed and the Douglas pouch sutured again. No dilation of the sphincter is necessary because of its relaxation after general or lumbar anesthesia (the latter being preferred by us).

Hochenegg suggested removing the mucous membrane of the sphincteric segment prior to undertaking the pull-through, as is customary in the Whitehead operation for hemorrhoids (Fig. 2). Disinfection of the sphincteric portion is done by repeated painting with tincture of iodine (10 per cent) from

the anus, following which the clamp holding the sphincteric portion is removed (*a* to *b*) and the mucous membrane eventually extirpated. All these manipulations need not imply the slightest injury to the internal sphincteric muscle. Kocher advocated leaving the mucous membrane intact, a method attended by advantages but by disadvantages, too. Control of hemorrhage after extirpation of the mucous membrane is time consuming and often difficult, requiring a very high degree of accuracy. On the other hand, aseptic conditions are more easily maintained if the mucous membrane is removed, because effective disinfection of the sphincteric mucous membrane is no easy task, and the mucosa, if it is left in place, naturally continues its secretory activity and the presence of secretion between the sphincteric mucosa; the serosa of the part of the bowel which has been pulled through provides a serious obstacle to healing. Experimental and microscopic studies (Gara and Mandl) showed that the growth of adhesions between the mucous membrane and the serous surface occurs either very late or not at all. Where mucosa and serosa are in contact, the glandular structure of the mucosa is preserved while the serosa becomes subject to necrosis. There is, moreover, the possibility that mucous cysts may form and the main factor in the production of fistulas is the attempt of the secretion to find an escape. Removal of the sphincteric mucous membrane prior to the pull-through operation is, therefore, commendable (see Case Reports).

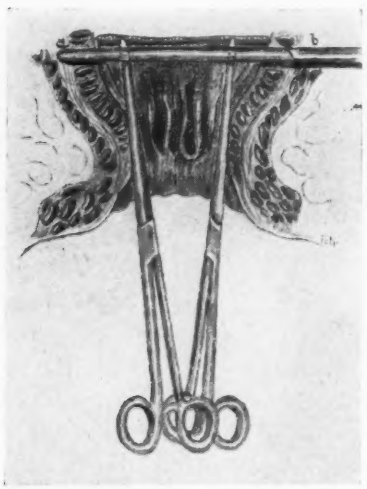

Fig. 2.

Fig. 3.

Fig. 2.—Manipulations on the sphincteric segment. The lowest clamp (see Fig. 1) is left in place until after disinfection of the sphincteric portion and is then removed. Following this, the mucous membrane is removed by grasping the clamps and pulling them directly through the sphincter, under strict control of hemorrhage and avoidance of injury to the muscles.

Fig. 3.—Primary pull-through completed. The Douglas sac is closed. The segment of bowel which has been pulled through shows no tension and is of normal appearance. Where the two bowel segments are invaginated into each other, we have placed interrupted sutures (*a*). The bowel has been pulled through far beyond the anus and will be amputated several days later. At its base, note stitches between the skin of the anus and the external layers of the bowel.

Another method has been practiced at my department for a number of years now. The entire sphincteric segment is sharply divided by a vertical incision, folded apart, the mucosa disinfected, and then extirpated in toto. The peripheral colonic segment is then placed into the wound and the vertical incision closed by suture throughout all its layers. No doubt this method allows the whole operative procedure to be conducted under the guidance of the eye,

but it has nevertheless been abandoned by us in view of the frequent occurrence of infection, which forestalls any possibility of restoring continence later.

3. *The bowel segment pulled through the anus* should protrude beyond it (Fig. 3), and any shortening is inopportune since it is likely to cause shrinkage or necrosis of the colonic segment. From the small number of illustrations available in the literature so far published, it can be concluded that the bowel segment used for the pull-through is severed just above the anus and approximated to it by circular suture. In my opinion, there is nothing to recommend such methods. Our procedure is to fix the base of the protruding bowel between skin and serosa with interrupted sutures. The sutures placed within the wound, in addition to those between the sphincteric segment and the other part, are, as a general rule, sufficient to prevent the bowel from slipping back (Fig. 3).

The portion protruding beyond the anus is *later* amputated by electrocautery.

E. Aftertreatment.—Because as the operation has, as a rule, been preceded by colostomy, the evacuation of feces involves no problem at all. If, for some reason, no preliminary colostomy has been made, the patient should, after the customary emptying of the bowel, be given eight drops of tinctura opii three times per day for the duration of eight days after operation. On the tenth to twelfth day, bowel movement should be encouraged by oily laxatives. As a general rule, unless there is a special reason, digital exploration should be postponed until after the tenth day. After the lapse of a fortnight, it is even useful for the relief of the mild degree of stenosing usually present at the pull-through point. Even bougies may be used. Repeated examinations are indispensable, particularly as the colostomy can be closed only after the peripheral wound has healed satisfactorily and there are no fistulas. On the first few days, following operation, voluntary innervation of the sphincter cannot be expected, or at least only in a very superficial manner. Systematic exercises may, however, improve conditions remarkably. They are of outstanding importance for the rapid restoration of continence.

F. Complications.—

1. *Infection:* Infection, if it occurs, is usually due to gangrene of the bowel segment pulled through the anus. This is also the point where the danger of toxemia must be considered (sulfanilamide prophylaxis). A positive result of the operation can, in such a case, no longer be expected. The wound should be exposed and typical wound treatment instituted. The fistula thus established may later be closed.

2. *Fistulas:* There is always a certain percentage of cases in which small fistulas occur (see Case Reports). Unless there is gangrene of the bowel, the majority of them are amenable to conservative measures (rinsing with disinfectants, warm hip baths, postponement of the closure of the colostomy). Generally, they develop at the posterior circumference of the bowel, which has been pulled through, and open into the sacral wound.

3. *Slipping back of the bowel segment pulled through the anus:* The segment pulled beyond the sphincteric portion may become subject to necrosis and is then spontaneously, although gradually, cast off up to a certain height. Fistulas are rather common, but the internal suture between the two parts (Fig. 3) may nevertheless ensure smooth healing with satisfactory sphincteric function. Where this occurs, stenosing may (although it should not) take place which requires systematic dilatation after the wound has healed.

II. The Secondary Pull-through Method

The secondary pull-through method must be resorted to in two instances:

A. During radical operation for rectal carcinoma, when the primary pull-through operation is envisaged but the length of bowel possible to mobilize proves insufficient or its peripheral segment of poor vitality, the operation must be terminated by the construction of a sacral anus. The sphincteric portion is nevertheless spared (Fig. 4) and its upper extremity closed by a firm suture.

B. Either the primary pull-through method or circular suture (Kraske method) is originally performed, but because of infection, partial gangrene, or slipping back of the bowel, a sacral anus forms by itself. The sphincteric portion is left in place, as it is in accordance with the whole plan of the operation

Fig. 4.—Diagram of sagittal cross section after mobilization of the rectosigmoid and construction of a sacral anus since mobilization of a considerable length of well-supplied bowel down to the sphincter had not been possible. After suturing of the Douglas pouch, a sacral anus was, therefore, made. The sphincteric portion (see Fig. 1, *a-b*), held by a clamp, will be ligatured by a strong thread and buried in the depth.

In the course of time the sacral anus of the proximal segment may develop prolapse which Weil used, after invagination so that the mucosal covering was again on the inside, to perform a secondary pull-through operation. Any surgeon may be confronted with such an emergency. Thus Hochenegg's archives contained the records of a few successful operations of this kind. Beyond that, I could show that this prolapsing could be *artificially* promoted and a secondary pull-through operation thus made possible. (See References, Mandl.)

First of all, one should realize what the anatomic preconditions are that lead to prolapse. There are (1) insufficiency of the soft and bony pelvis floor, (2) low pouch of Douglas, (3) insufficiency of the rectal attachments, (4) increased abdominal pressure by exaggerated activity of the abdominal musculature. No doubt, the soft as well as the bony pelvis floor loses some of its efficiency after radical operation for rectal carcinoma and resection of the coccyx and sacrum.

If the pouch of Douglas reaches down to a low level, the cul-de-sac is opened during radical operation, the bowel extracted from the small pelvis, and the suture placed as low as possible, a procedure likely to produce prolapsing. There can be no doubt that extensive mobilization of rectum and colon is attended by the risk of damaging the rectal attachments. If the patient is further encouraged to make systematic exercises ("as though he were going to have stools"), increasing the intra-abdominal pressure by pressing, every day for several hours, everything is done to promote prolapsing of the sacral anus. Actually, a method has been developed on the basis of these considerations which may be described as "the artificial production of prolapse from sacral anus," facilitating the secondary pull-through operation. (Fig. 5.)

A typical circumcision is made around the prolapse, the external segment invaginated with the mucosa on the inside (like a glove turned inside out), which provides the length of bowel necessary for the pull-through manipulation. If the pouch of Douglas gets punctured during this procedure it is sutured in the same way as during the primary operation. As a rule, however, one encounters only adhesions in which blood vessels have to be ligated. An incision is then made through the soft parts, stretching from the sacral anus to just above the normal one (Fig. 5, *a* and *b*). The sphincteric segment left in position during the main operation and ligated at its proximal extremity, as a rule, completely grows together, so that a circular excision (Fig. 5, *c*) has to be made before the prolapsing portion can be pulled through.

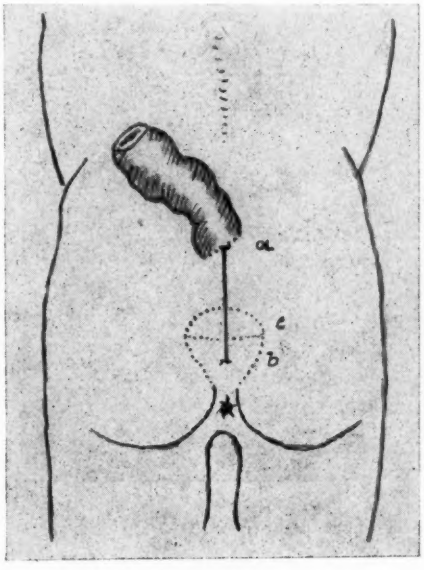

Fig. 5.

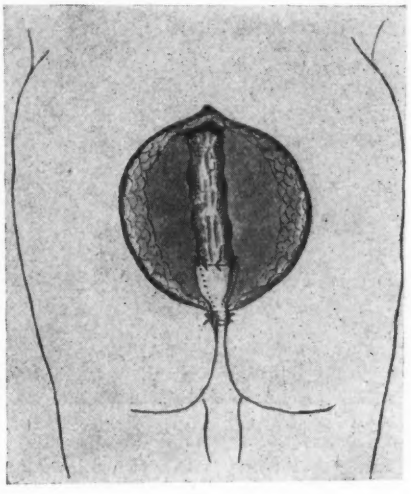

Fig. 6.

Fig. 5.—Secondary pull-through method. A few months after radical operation the sacral anus has developed into a prolapse which, in the diagram, has been turned upward. The procedure is, after circumcision at its circumference, to turn it inside out, so that the mucous membrane is now on the inner side, following which an incision is made from *a* to *b*, that is from the base of the prolapse to just above the natural anus. The roof of the sphincteric segment, which is left in place, usually grows together and has to be resected by circular excision (*c*), following which the prolapse can be pulled through the soft parts and the sphincter.

Fig. 6.—Diagram of completed secondary pull-through operation. Note inside suture at the bowel and those on the outside similar to Fig. 3.

It is interesting to note that the degeneration of the mucosal lining of the sphincteric portion owing to many months of idleness provides a much less formidable obstacle to its healing smoothly to the serosal covering of the bowel which has been pulled through, than the conditions created by primary pull-

through operation. The excision of the mucous membrane in the secondary method, which is not done before several months have elapsed following radical operation, is not, therefore, an indispensable measure. The operative technique is illustrated by Figs. 6, 7, and 8.

I have reported upon a number of successful operations according to this method in the course of the past few years. By others it has only been mentioned without statistical data being added (Goetze). Only my former collaborator, Ebner, mentions the fact that exercises in abdominal pressure were routine at the Second Surgical Department of the University Clinic in Vienna, and that, as a consequence, the number of secondary pull-through operations could be considerably enlarged. Ebner tried to carry the idea even farther. Careful studies of the abdominal pressure by means of colpeurynters introduced into the ampulla recti revealed quite high values (up to 190 mm. Hg). The mean values were found highest in defecation position, lower in knee-elbow position. It is, therefore, pressing "as though to have stool," recommended by me in 1925, that is the most successful method to obtain prolapse. In the great number of patients who, after resection of the rectum, had been encouraged to make systematic abdominal exercises, Ebner distinguished, one year after primary operation, three types: (1) Those in whom prolapse had occurred from a wide sacral anus as a suitable aperture, (2) those in whom no prolapse had occurred but who had a sacral hernia. In such cases, the sacral anus is narrow and scarred, the sigmoid and mesosigmoid long, which could be verified by x-rays and digital examination, and (3) those in whom neither prolapse nor hernia has occurred.

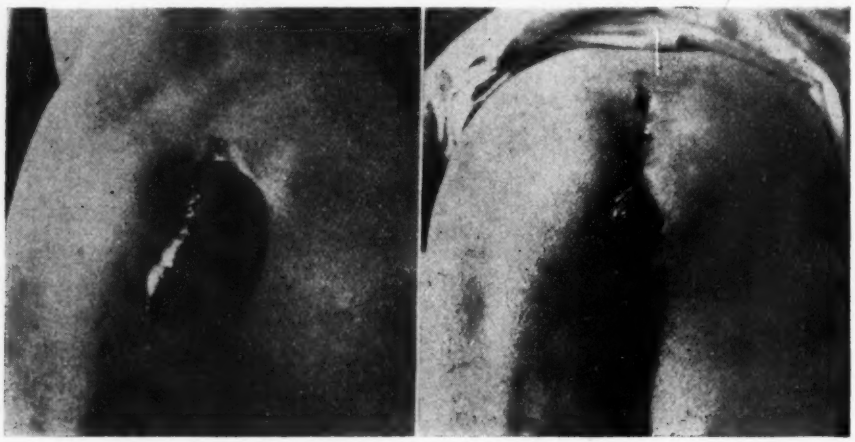

Fig. 7. Fig. 8.

Figs. 7 and 8.—Patient with artificial prolapse from sacral anus before and after secondary pull-through operation (From Felix Mandl: Arch. f. klin. Chir. 136: 479, 1925.)

I have performed the secondary pull-through operation on all three types without discrimination. It is clear, however, that types 1 and 2 are more suitable objects for this operation. Ebner reported eight successful secondary pull-through operations in the presence of hernia without prolapse (type 2). Type 3 naturally presents difficulties. The scar tissue has to be resected and the stenosed sacral anus reamputated. Ebner reported success in two such cases. Unfortunately, no exhaustive statistical data covering the whole of his material are available.

Be this as it may, the method advocated by me, consisting in the establishment of an artificial prolapse from the sacral anus, providing a new way to pre-

pare the secondary pull-through operation, is a very simple measure. Although it is very distasteful to the patient, for the duration of many months, to put up with having two artificial ani (one in the transverse colon through which the feces pass and another in the sacral region from which, providing a normal function of the first, only mucus escapes), skillful persuasion will help him over this uncomfortable and inconvenient period.

During the pressing exercises, the patient should be warned forcibly to press back the abdominal anus with his hand, since otherwise the prolapsing may occur in the abdominal rather than in the sacral anus. Our experiments with a view to promote prolapsing by means of a cupping glass were also rather successful.

THE CLOSURE OF THE COLOSTOMY

Since in my opinion success or failure of primary or secondary pull-through operations to a high degree depends on the preliminary establishment of a colostomy, a few remarks on this operative procedure seem indicated. It has recently been pointed out that the radical removal of rectal carcinoma should be done in one stage. If the sphincter, for some reason, cannot be spared, I also practice this method, preferring the one-stage operation according to Miles, especially since it is a common experience that patients may be as severely taxed by colostomy as by radical operation. Nevertheless, I am convinced of the necessity of constructing a colostomy prior to proceeding to the pull-through operation. The surgeon should not forget, however, that when making a colostomy it is his concern to provide for its later closure, which should be as simple as possible. In this respect the "double-barrel colostomy" devised by Mikulicz is a very suitable method. If it is carried out correctly, its closure by a Mikulicz clamp, which is introduced into the two limbs of the bowel, is a very simple procedure. Crushing of the spur by means of the clamp saves, in the majority of cases, major operative measures. Parts of the colonic mucous membrane protruding over skin level are removed by electrocautery, a procedure which must be repeated again and again until the skin grows over the two foramina. If the peripheral bowel is pervious, operative closure of a colostomy, implying opening of the peritoneum, is very rarely necessary. The most instructive illustration of the method, which I have been practicing for many years, and which is in agreement with Mikulicz's directions, is contained in a paper by Moskowicz. Where this method is impracticable, I am using, for the intra- or extraperitoneal closure of a colostomy, that described by Bacon.

The method outlined here has undoubtedly contributed much to the possibility of restoring continence in a far greater number of patients than was originally thought possible. Its adoption by wider circles will give surgeons the necessary experience to improve the results even further.

MY OWN MATERIAL

A large part of my operative records have been lost owing to political complications, but my publications continued up to the year 1940. Where I am working now and have but limited material at my disposal, I have nevertheless performed fifty-four radical operations for rectal carcinoma (from 1939 to 1944) in seventeen patients (that is 31.4 per cent) in whom I attempted to maintain continence primarily *or* to restore it, after preservation of the sphincter, by a secondary pull-through operation. The records on these cases are *complete*, and give a good idea of the pros and cons and even dangers of the method.

Case reports are given as concisely as possible and no reference to malignograms has been included.

REPORTS OF CASES

I. Radical Operation for Rectal Carcinoma With Subsequent Primary Pull-Through Operation (Eight Cases).—Normal healing without formation of fistulas, by first intention, with complete restoration of continuity (seven cases) (Fig. 9).

Apart from one patient who died after radical operation followed by primary pull-through, there are seven cases at our disposal.

CASE 1.—The patient was a man of 60 years, operated upon in February, 1938 (in Vienna). The site of the tumor was about the pouch of Douglas and the combined abdomino-sacral approach was used after preliminary construction of a colostomy. This was followed by a pull-through operation and healing occurred by first intention. In the course of the year 1939 the colostomy closed spontaneously. Follow-up examination in 1944 showed no recurrence and perfect continence.

CASE 2.—The patient, a man 39 years of age, was a physician. He had a tumor 15 cm. from the anus. Nov. 6, 1939, colostomy was constructed on the transverse colon. Nov. 21, 1939, extended sacral operation was done with primary pull-through. Dec. 25, 1939, there was operative closure of the colostomy followed by healing by first intention. The patient joined the British Forces in 1940 and is doing front-line service. He reports perfect continence.

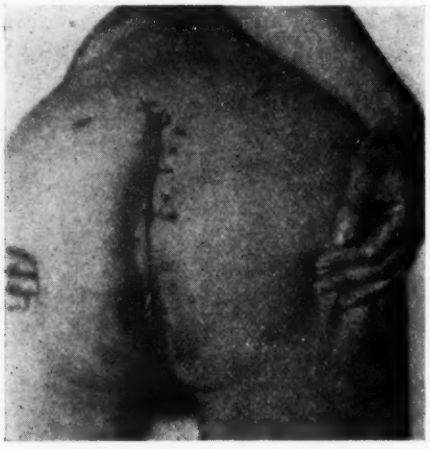

Fig. 9.—Patient after primary pull-through operation. Healing took place by first intention, a fortnight after radical operation and after amputation of the protruding bowel.

CASE 3.—The patient was a woman, 50 years of age, with a tumor approximately 10 cm. from the anus. As she was very obese, no colostomy was made. May 20, 1940, extended sacral operation was done with primary pull-through and resection of 45 cm. of bowel. Healing occurred by first intention. Follow-up (August, 1944) showed no recurrence and perfect continence.

CASE 4.—The patient was a man of 33 years, with carcinoma 8 cm. from the anus. June 11, 1941, colostomy was made on the transverse colon. June 26, 1941, radical operation (extended sacral method) was followed by primary pull-through, 30 cm. of bowel being resected. Healing occurred by first intention. In January, 1942, the colostomy was closed. Follow-up (October, 1944) showed no recurrence and perfect continence, while the only complaint the patient had was of sexual impotence.

CASE 5.—The patient was a woman, aged 50 years, who had a tumor 8 cm. from the anus. Sept. 8, 1941, colostomy was constructed on the transverse colon. September 28, extended sacral operation was done with primary pull-through. Healing occurred by first intention. On Oct. 22, 1941, the colostomy was closed. Follow-up (May, 1944) showed no recurrence and continence was perfect.

CASE 6.—The patient was a woman of 45 years, with rectal carcinoma 12 cm. above the anus. June 3, 1939, colostomy was made on the transverse colon. June 18, 1939, radical operation (extended sacral method) with resection of 38 cm. of bowel (Fig. 10), was followed by primary pull-through. Healing occurred by first intention. Sept. 20, 1939, the colostomy was closed. The patient died Aug. 2, 1942. Autopsy record showed no local recurrences, large cerebral metastasis in the right frontal lobe, and others in the right suprarenal gland. Death was caused by the cerebral metastasis.

CASE 7.—The patient was a man, 44 years of age, with a polypous tumor 9 cm. from the anus. April 30, 1943, colostomy was made on the descending colon. May 21, 1943, radical operation (extended sacral method) was done with primary pull-through. Healing occurred by first intention. Two attempts to close the colostomy operatively failed. However, in December, 1943, it closed spontaneously. Follow-up (September, 1944) showed no fistula, no recurrence, some weakness of the sphincter which, although able to cope with normal stools, showed a certain deficiency if the stools became diarrheic.

Fig. 10.—Development of sacral hernia from sacral anus. The sphincter had been preserved.

II. Primary Pull-Through Operation Followed by Fistulas, Their Response to Treatment and End-Results (Six Cases).—

CASE 1.—The patient was a woman of 66 years with a tumor 8 cm. from the anus. On Aug. 18, 1940, extended sacral operation was performed without preliminary colostomy, with resection of 20 cm. of bowel followed by primary pull-through. Recovery was complicated by urinary infection, pulmonary infarction, cardiac failure, and severe mental depression. Just above the normal sphincter a fistula had formed. Rectal examination showed that the bowel had slipped back. The patient was discharged Dec. 1, 1940, after all complicating symptoms had subsided. Although she still had a fistula from which, during defecation, a strip of feces the thickness of a match escaped, her condition was quite satisfactory, as there was a normally registered desire for stool and full continence. Treatment consisted in rivanol irrigation (1:2000) and warm baths. In December, 1941, the woman suddenly died, apparently from heart failure.

CASE 2.—The patient was a woman of 38 years, with a tumor situated at three finger widths above the pouch of Douglas. Nov. 25, 1943, a colostomy was made in the transverse colon, followed, Dec. 6, 1943, by extended sacral operation with resection of 20 cm.

of bowel and primary pull-through. The mucous membrane of the sphincter was left intact. The segment of bowel which had been pulled through slipped back and sacral fistula formed. The colostomy of the transverse colon did not function normally either, and feces passed through the lower colonic segment. A new colostomy was, therefore, made proximally to the original one, also in the transverse colon. As early as four weeks later, the sacral fistula closed. On digital exploration, it was found that there was a free communication between the sphincteric portion and the bowel which had slipped backed and there was neither stenosing nor any detectable defect. Even on pressure or rectoscopy, no internal fistulous opening was recognizable. However, before the colostomy could be closed, diffuse metastasizing occurred in the lungs (Oct., 1944) so that the plan had to be abandoned.

CASE 3.—The patient was a man, 48 years of age, with a tumor which could only be established on rectoscopy as lying at a distance of 18 cm. above the anus. Nov. 15, 1943, a colostomy was made in the transverse colon which, however, severely taxed the patient, who was suffering from angina pectoris and myocardial insufficiency. Dec. 31, 1943, extended sacral operation was done. The tumor was found at approximately three finger widths from the Douglas fold. Although the mesosigmoid was short, it was possible to resect 16 cm. of bowel up into the healthy tissue, and the sigmoid loop could be pulled through the anus (primary method). To shorten the operation, the mucosa of the sphincteric portion was left in place. The patient stood the radical operation better than the colostomy. A small sacral fistula developed which was improved by baths and rivanol irrigations, while its complete closure, under ambulant treatment, did not occur before May, 1944. By October, 1944, the patient had no fistula and the peripheral intestinal segment was in perfect order. Owing to his heart condition, the closure of the colostomy was postponed, the opening, however, shrinking more and more and as the patient informed us, no more than about one-third of the feces passed through it while the remainder left the bowel by the natural way, with full retention and normal sphincteric function.

CASE 4.—The patient was a man of 36 years, with a tumor about 16 cm. above the sphincter. Dec. 23, 1944, colostomy was performed on the transverse colon, followed, on Jan. 7, 1944, by radical operation (extended sacral method with primary pull-through). The mucosa of the sphincteric region was left intact. It was, however, possible to place a great number of sutures between the part of the bowel which had been pulled through and the sphincteric portion. Thirty centimeters of the bowel were resected. Recovery was normal, but a small sacral fistula developed which could be brought to closure by a four months' ambulant treatment. Follow-up examination (August, 1944) showed no recurrence and perfectly normal functioning of the peripheral intestinal portions. The patient was advised to have the colostomy closed to which he finally agreed in December, 1944. The patient was cured and discharged from the hospital with perfect continence.

CASE 5.—The patient was an extraordinarily obese woman of 47 years, with a tumor 8 cm. from the anus. No preliminary colostomy was made. March 11, 1944, extended sacral operation was performed with resection of 12 cm. of bowel. There was a hemorrhage from the sphincteric portion which had been deprived of its mucous membrane, which could, however, be arrested by tamponing. The hemorrhage did not cause her any harm, but owing to either the packing or the pressure of the hematoma, partial necrosis occurred in the intestine and two sacral fistulas developed. Healing under ambulant treatment was complete in August, 1944, although no colostomy had been made. Follow-up examination (October, 1944) revealed a small sacral fistula, the channel being the width of a match, with some discharge of secretion occasionally allowing the escape of feces, and full continence. No surgical intervention was, therefore, deemed necessary.

CASE 6.—The patient was a woman, aged 32 years, presenting a high, rectosigmoidal tumor. Dec. 15, 1943, colostomy was established in the transverse colon and on that occasion no metastases were noted in either the liver or colon. January, 1944, radical operation with primary pull-through was performed by the sacral approach. The bowel segment used for the pull-through developed gangrene, the wound had to be re-opened, and a sacral anus formed. An attempt to induce the sacral anus to prolapse by the pressure method outlined previously was successful. In April, 1944, it had already grown to a length that allowed the performance of a secondary pull-through operation. At that time the patient began to complain of abdominal symptoms and developed ascites. After withdrawal of fluid the metastases could be felt in the liver. The idea of a secondary pull-through operation was, therefore, abandoned. The fluid was several times drawn off and the patient died in a cachectic condition in August, 1944.

III. Secondary Pull-Through Operation After Radical Operation With Preservation of Sphincter Ani.—

CASE 1.—The patient was a woman, aged 63 years, with carcinoma 12 cm. above the anus, with circular stenosis. Oct. 30, 1940, colostomy of the transverse colon was constructed. Nov. 17, 1940, extended sacral operation was done. The sphincter was not touched, after 45 cm. of bowel had been mobilized. The tumor was above the pouch of Douglas. Together with the carcinoma, two polypi had to be removed. Owing to shortness of the colon, the operation was terminated by construction of a sacral anus. The sphincteric portion was ligated and buried. Recovery was interrupted by various complications (thrombophlebitis, pulmonary infarction) and not before July, 1941, could the patient be discharged. By encouraging the patient to make pressure exercises it was possible to induce the sacral anus to prolapse, so that soon sufficient length of bowel was available to be pulled through the sphincter which had been left intact (July 27, 1941). Healing was normal and no fistulas formed. Continence was fully restored. Toward the end of 1941, the patient developed severe polyarthritis with high temperature and myocardial insufficiency. She died toward the end of 1942 from acute cardiac disease. Clinically, neither local recurrence nor metastasizing could be detected. Since the patient died at home, no autopsy was made.

CASE 2.—The patient was a man, aged 40 years, a waiter, with a family history of carcinoma. Eight centimeters from the sphincter, there was a tumor of the posterior bowel wall. June 9, 1943, colostomy was performed on the transverse colon. June 30, 1943, radical operation (extended sacral method) was done. The sphincter could be spared. Owing to shortness of the bowel that could be mobilized, primary pull-through operation proved impossible and a sacral anus was established instead. The sphincteric segment was ligated and buried. The patient was encouraged to make pressure exercises and by October, 1944, a prolapse approximately 4 cm. long had protruded from the sacral anus. As there was no recurrence, secondary pull-through operation was performed with satisfactory result in January, 1945.

CASE 3.—The patient was a man of 36 years, who was admitted to the hospital in November, 1942. He had a stenosing tumor, at 15 cm. distance from the anus, for which rectoscopically as well as microscopically a diagnosis of carcinoma of the recto-sigmoid was made.

A preliminary colostomy was established in the transverse colon and on that occasion we satisfied ourselves that no metastasizing had so far occurred into the abdominal cavity. Radical operation (extended sacral method) followed on Dec. 11, 1942, during which 30 cm. of bowel were resected, together with its lymph nodes, and a sacral anus established after preservation of sphincters. The lymph nodes showed no microscopic evidence of malignancy. Healing was smooth.

Follow-up examination (November, 1944) showed a sacral hernia, the size of a man's fist, in a patient of an otherwise satisfactory state of general health, with normally functioning colostomy. The sphincteric segment which had been left in place on the occasion of the radical operation, had grown together at its upper circumference.

Jan. 4, 1945 operation was done on sacral hernia. A large segment of bowel, after dissecting off its adhesions to the Douglas pouch, was mobilized. An incision was made at a level between the base of the hernia and the upper part of the sphincter, and the "roof" of the latter reopened. The portion of bowel mobilized from the sacral wound was then pulled through the sphincter, the mucosa of which was left intact. The part used for the pull-through was in a normal state of nutrition and protruded by approximately 7 cm. from the natural anus. This protruding portion was later amputated. The sacral wound healed without fistulas (with some rehiscence of skin). The passage between the sphincter and the large intestine was free. On Jan. 14, 1945, the colostomy was closed by means of a Mikulize clamp.

STATISTICS

In seven out of fifteen cases (after deduction of one fatal case) primary pull-through operation was done with satisfactory results that is, in 46.6 per cent) (Group I).

In Group II statistical calculations are difficult since in one of the cases the colostomy has not yet been closed, although there is every chance that the patient will have continence restored. Cases 1 and 5 regarding continence, can be con-

sidered as successful, while Case 6 was a complete failure. Owing to the diversity of the material, no accurate percentages can be given and it should be left to the reader to form his own opinion.

The secondary pull-through method was done, for external reasons (scarcity of beds available in the hospital), on only three patients, with good results in all.

In twelve out of sixteen cases, therefore, that is in 75 per cent, continence could be restored either by primary or secondary pull-through operation (excluding the one case in which the colostomy has yet to be closed).

SUMMARY

Guided by the idea that the restoration of continence is of prime importance, any radical operation which does not arrange for this possibility, although it would not imply loss of radicality, is regarded as imperfect. After referring to the methods suggested for this purpose in the Anglo-American, the French, and the German literature, the technique of the primary (Hochenegg) and the secondary (Weil) pull-through method is described, the latter by "artificial production" of prolapse (Mandl) from the sacral anus and operation on the sacral hernia. The pull-through procedure may be used equally as well after dorsal (sacral) or combined (abdominosacral) radical operation. So far the method devised by Hochenegg holds the greatest promise of success, regarding the restoration of continence after operation on the rectosigmoid, provided the indication is strictly adhered to. Nevertheless, it could be employed in only a certain number of cases of carcinoma (31.4 per cent of all cases) and was, in 46.6 per cent, followed by smooth healing by first intention. This percentage was further increased by adequate treatment of complications and by secondary pull-through operation, to 75 per cent.

A complete list of case records for the past five years is added.

It is pointed out that colostomy should precede the pull-through operation. Technical details are described. The method may be further developed.

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ACUTE COLONIC OBSTRUCTION SECONDARY TO CARCINOMA OF THE SIGMOID COLON WITH GANGRENE OF AN EXTENSIVE SEGMENT OF THE LARGE BOWEL

A Case Report

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ACUTE mechanical obstruction of the colon due to carcinoma is not an uncommon occurrence. In the presence of a competent ileocecal valve, which allows the entrance of intestinal contents into the cecum but prevents the reverse flow of cecal contents into the ileum, extreme dilatation of the colon proximal to the site of obstruction and perforation of the cecum is the usual course of events, if prompt decompression of the obstructed bowel is not effected. An occurrence of gangrene of an unusually large segment of the colon coming on nine hours after the onset of symptoms of obstruction appears sufficiently noteworthy to merit mention in the surgical literature.

CASE REPORT

A 43-year-old white soldier was admitted to an Army General Hospital at 1 P.M., May 14, 1944. The evening before he had felt quite well, had worked for several hours, and had gone to bed around midnight. On awakening around 6 A.M., May 14, 1944, he experienced some mild lower abdominal cramps which became progressively more severe in the next hour, associated with abdominal gurgling noises. He had one small, apparently normal bowel movement shortly after the onset of the cramps, following which he passed no further gas or fecal matter by rectum. The cramps increased in severity throughout the morning and about three hours after the onset of his illness a progressive distention of the abdomen was noted along with a continuous pain between cramps. The patient felt nauseated but had no emesis.

About five weeks prior to this illness the patient had a similar, but milder, episode which lasted several hours and then spontaneously disappeared. His bowel habits and movements had been apparently normal. About ten months previously the patient had had a thorough gastrointestinal study in the United States, including colon x-ray and proctoscopic studies, following an attack of diarrhea. These studies apparently had yielded no positive results.

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Physical examination shortly after admission to the hospital revealed an acutely ill, white man, 43 years of age. Temperature by rectum was 100° F., pulse rate 124, blood pressure 100/60. The abdomen was tensely distended and rigid throughout. There was marked tenderness in all quadrants of the abdomen. Because of the extreme distention and rigidity it was difficult to elicit rebound tenderness. On auscultation of the abdomen for a ten-minute period, no borborygmi could be heard. On digital examination of the rectum a tender boggy indefinite mass in the cul-de-sac could be felt. There was no blood noted in a small piece of fecal matter removed with the examining finger.

A scout x-ray film of the abdomen revealed a markedly dilated loop of colon occupying the area of the hepatic flexure (Fig. 1). The splenic flexure was moderately dilated with gas extending down into the area of the sigmoid colon. Study of the patient's urine revealed no abnormalities other than 15 to 20 white and red blood cells per high-powered field and fairly numerous granular casts. The white blood count was 9,100 of which 85 per cent were polymorphonuclear cells, 14 per cent lymphocytes, and 1 per cent monocytes.

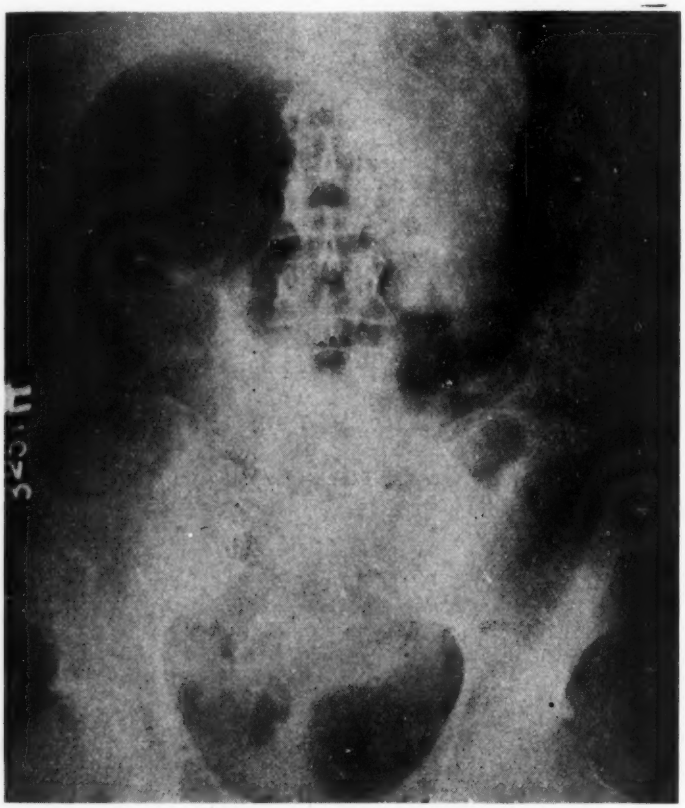

Fig. 1.—Scout x-ray film of the abdomen showing extreme dilatation of the right colon.

A diagnosis of possible volvulus of the sigmoid colon or acute mechanical obstruction of the sigmoid colon, possibly due to carcinoma, was made. After receiving 500 c.c. of plasma the patient was taken to the operating room.

The operation was started at 3 P.M. under ether-oxygen anesthesia through a lower abdominal left rectus incision. When the peritoneal cavity was entered, about 1,000 c.c. of brown, foul-smelling peritoneal fluid was encountered. (A culture of this fluid subsequently revealed no growth of any organisms after forty-eight hours.) The colon was found to be enormously dilated and gangrenous. Because of the extreme distention it was impossible to mobilize the bowel sufficiently at this stage of the operation to ascertain the extent of the involvement. To gain exposure, the upper end of the left rectus incision was extended laterally and to the right, above the umbilicus, to beyond the lateral border of the right rectus muscle. In this manner satisfactory exposure was obtained. The entire colon from ileocecal valve to the midportion of the descending colon, where the process faded off to healthy looking bowel, was found to be gangrenous. There were several serosal rents over the cecum and ascending colon but no perforation had occurred. The terminal ileum was of normal size and appearance. In the sigmoid colon, about 15 cm. above the peritoneal reflection, was a small, annular,

constricting, napkin ring-shaped tumor, about 3 to 4 cm. in diameter. Because of the gangrene of the colon no procedure other than colectomy was feasible. This was started by transecting the ileum about 4 cm. proximal to the ileocecal junction. Colectomy (Fig. 2) was then undertaken beginning at the cecum and progressing down the colon to about 5 cm. below the carcinoma. No spillage occurred during this procedure. No enlarged lymph glands or metastases of the carcinoma to other organs were noted. The stomata of the distal portion of the sigmoid colon, a segment about 10 cm. above the peritoneal reflection, and the terminal ileum were brought out side by side through the left rectus part of the incision. The remainder of the operative wound was closed in layers without drainage. During the operative procedure, which lasted three hours, the patient received 1,000 c.c. of whole blood, 750 c.c. of plasma, and 1,000 c.c. of normal saline. At the completion of the operation the patient's condition was satisfactory, the blood pressure was 118/70, and the pulse rate was 140.

Postoperatively the patient had continuous suction applied to an indwelling nasal gastric tube and to a catheter in the ileostomy stoma for three days. He received penicillin at three-hour intervals intramuscularly, 240,000 Oxford units in all being given daily for three days, then 120,000 units for two days when it was discontinued. Aside from a moderate wound infection about the ileostomy stoma, the patient's postoperative course was satisfactory. The highest postoperative temperature was 101.8° F. by rectum on the second and third postoperative days, after which it dropped to normal.

Fig. 2.—Colon at the time of operation with the cecum and the appendix from which a forceps is hanging held uppermost. The color change of the black gangrenous colon can be compared to the color of a normal loop of ileum seen below in the operative wound.

Pathologic Report (Fig. 3).—The specimen consisted of a segment of colon (sigmoid through cecum) 137 cm. long and attached appendix and 4 cm. segment of ileum. At the cecum it measured 14 cm. in diameter and toward the distal end 6 cm. in diameter. At a point 5 cm. above the distal plane of excision there was an annular, constricting, ulcerated, indurated tumor 4 cm. long. The lumen was reduced to about 1 cm. in diameter. On section the entire wall of the bowel was indurated and the overlying adipose tissue was adherent to a slightly granular serosal surface posteriorly. There were no nodes in the scant amount of attached mesentery. From a point 8 cm. above the tumor to the ileocecal valve, the entire wall of the bowel was black and softened, and became progressively thinner as the cecum was approached. There were several splits in the serosa over the cecum. The lumen contained gas and about three liters of watery fecal material.

Microscopic.—A section from the tumor showed the entire wall of the colon to be irregularly infiltrated with poorly differentiated glands and small nests of epithelial cells. The transverse colon showed necrosis, most extensive in the mucosa, extensive submucosal edema, and diffuse polymorphonuclear infiltration through the submucosa, serosa, and patchy in the muscularis. The cecum showed necrosis involving all layers of its wall. There were but a few isolated leucocytes.

Diagnoses.—Adenocarcinoma of the sigmoid colon and gangrene of the colon.

July 7, 1944, under combined intravenous pentothal and spinal metycaine anesthesia, the patient was reoperated upon. The colostomy and ileostomy stomata were dissected free and an end-to-end intraperitoneal ileosigmoidostomy was performed. On exploration at this time no evidence of recurrence of the carcinoma was noted. At the time this paper was submitted for publication, one month after the last operation, the patient is entirely well, and has about three soft, well-controlled bowel movements daily.

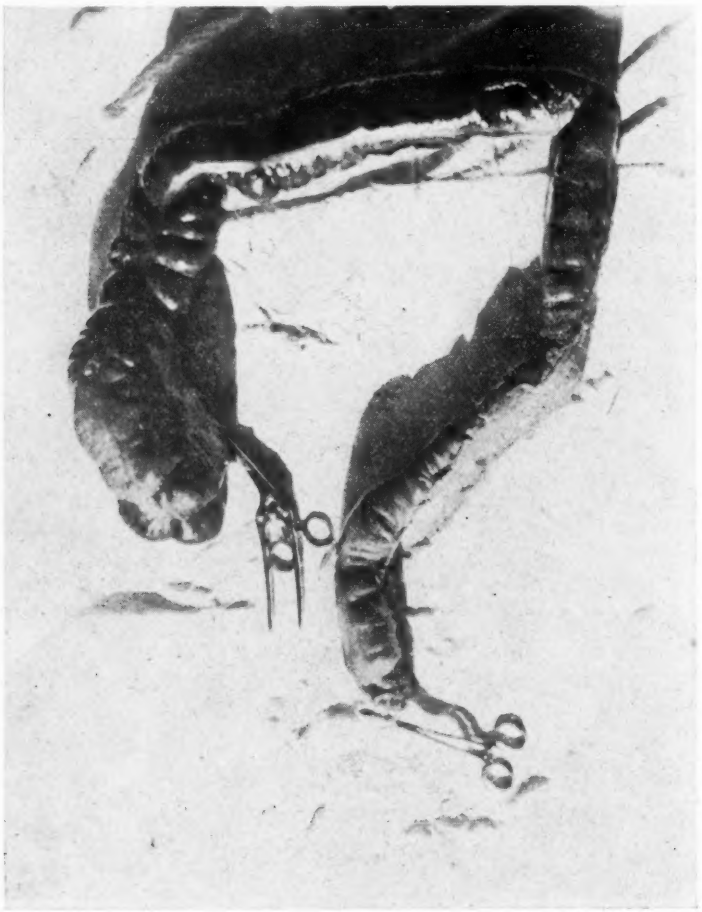

Fig. 3.—Resected specimen.

Wangensteen* has pointed out that, in the distention of complete large bowel obstructions, the intraluminary tension exerted on the cecal wall, because of its greater diameter, is greater per square centimeter than in any other segment of the colon. For this reason perforation of the cecum usually occurs before the intraluminary pressure becomes sufficiently high to compromise the viability of the remainder of the colon. This case is unique in that gangrene of the colon, from cecum to descending colon, occurred in the relatively short period of nine hours without resulting in perforation at the usual cecal site.

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THE USE OF A TRANSVERSE ABDOMINAL INCISION IN, AND COMMENTS ON, THE SURGICAL TREATMENT OF INFANTILE PYLORIC STENOSIS

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THE recent comprehensive review by Szilagyi and McGraw[1] of all phases of infantile pyloric stenosis makes an extended discussion of most aspects of the subject unnecessary at this time. These authors' historical review of surgical therapy, however, contains no mention of a type of abdominal incision which I have used for some time with such satisfactory results that I think it worth describing.

DESCRIPTION OF PROCEDURE

The steps of the operation are as follows:

1. A high transverse incision is made on the right side between the umbilicus and the ensiform cartilage, through the skin and subcutaneous tissues. A second transverse incision is made in the anterior sheath of the right rectus abdominis muscle. The sheath of this muscle is dissected free from the muscle fibers and retracted upward and downward (Fig. 1). The rectus abdominis muscle is dissected from the posterior sheath and retracted mesially. A third transverse incision is made in the posterior sheath of the muscle and the peritoneum (Fig. 2).

When the dilated stomach presents itself in the wound, as it does immediately upon the completion of the peritoneal incision, the prepyloric portion can readily be grasped and the hypertrophied pylorus delivered into the wound, where it is held between the left index finger and the thumb.

2. A modified Frédet-Weber-Rammstedt operation is carried out. Two longitudinal incisions are made in the hypertrophied pylorus through the serosal and muscular coats and the edges of both incisions are spread apart with Mayo dissecting scissors, so that the mucosa bulges into them. The pylorus is then released and is permitted to drop back into the peritoneal cavity.

3. After the intra-abdominal procedure has been completed, the posterior sheath of the right rectus abdominis muscle is closed with interrupted cotton sutures (Fig. 3). The retracted muscle is released and is permitted to return to its normal position. The incisions in the anterior sheath of the rectus muscle and in the skin are also closed with interrupted cotton sutures.

A compression dressing of fluffed gauze or cotton waste is placed over the wound and strips of elastic adhesive plaster are applied diagonally. Slight pressure is thus achieved, while at the same time there is no constriction that would interfere with respiratory movements of the chest and upper abdomen.

ANALGESIA

Local analgesia, which is often stated to be unsuitable for operations in very young children, will prove entirely practical if, when the child is placed on the table or shortly before, he is given a sugar teat made of a piece of muslin or of several thicknesses of gauze saturated with a solution of equal parts of whiskey and water, and is permitted to suck it throughout the operation.

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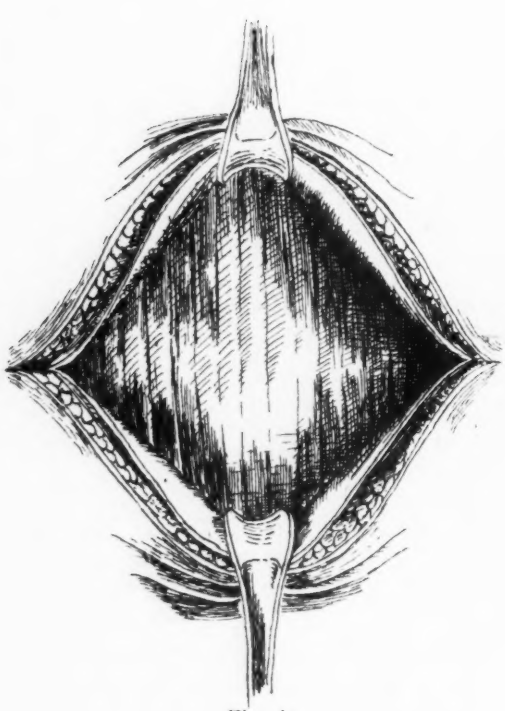

Fig. 1.

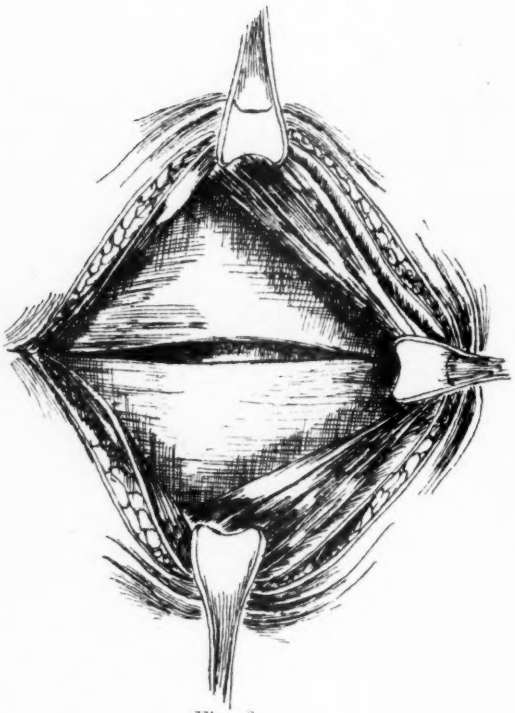

Fig. 2.

Fig. 1.—The right rectus abdominis muscle has been exposed by a transverse incision through the skin, subcutaneous fatty connective tissue, and anterior muscle sheath. The anterior sheath has been dissected from the right rectus muscle and is retracted upward and downward.

Fig. 2.—The right rectus abdominis muscle has been retracted mesially and a transverse incision has been made through the posterior sheath and the peritoneum.

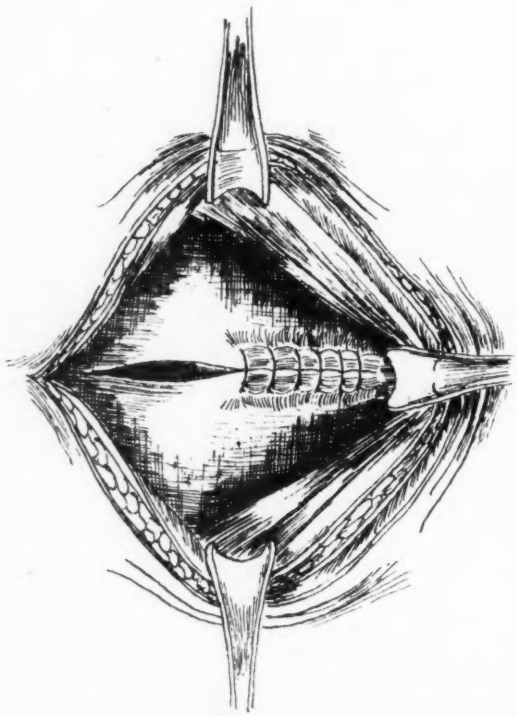

Fig. 3.—Closure of the wound has been begun by the use of interrupted sutures of quilting cotton in the posterior sheath of the right rectus abdominis muscle.

The abdominal wall and the operative field are blocked by the injection of a solution of 0.5 per cent novocain, very little of which is used in the fascia, muscle, and peritoneum. The perimeter of the injected area, however, should be sufficiently large to permit the incision to be made and the wound edges to be retracted without disturbing the child. If the initial injection is made correctly, the entire operation can be completed without a second injection.

DISCUSSION

Unquestionably, certain mild cases of pyloric stenosis can be treated satisfactorily by nonsurgical measures. On the other hand, if surgery were done promptly in all cases, the general results would undoubtedly be materially improved. The surgical results, particularly in America, have improved consistently over the years, but the death rate in this disease is still too high, chiefly because patients are held on dietary and medical treatment for long periods of time, the average physician or pediatrician being reluctant to recommend operation for infants. In short, as many writers have pointed out, a large part of the surgical mortality in pyloric stenosis is really nonsurgical in origin.

Part of the mortality in infantile pyloric stenosis, however, is also due to inadequate preoperative and postoperative care. To delay surgery for preoperative preparation is essential in the usual case and a wise precaution in almost every case, for the nutritional status of these infants is seldom optimum. A poor surgical risk can usually be transformed into a better one, or even into a good one, by such measures as the subcutaneous injection of physiologic salt solution, the intravenous use of physiologic salt solution combined with dextrose or with Hartmann's modification of Ringer's solution, and repeated small blood transfusions. If there is difficulty in administering these solutions by way of an arm or a neck vein, tibial puncture can be resorted to; the bony tibial cortex is not hard at this period of life, and usually entrance can be made with a very light rotating motion of the needle, although aseptic precautions must be taken. Injection by way of the longitudinal sinus is another possibility.

Preoperative medication, including all types of sedation, is unnecessary and may be actually injurious. The same holds true of gastric lavage and intranasal gastric intubation. Both of these measures tend to increase the incidence of respiratory complications, particularly aspiration pneumonia, and are never necessary if oral feeding is discontinued for twelve hours before operation.

Oral feeding is not resumed until twelve hours after operation, and the first feedings are at long intervals. The intervals are gradually shortened as the stomach adapts itself to the handling of food. If the infant has been breast fed, the maternal milk should be pumped out and used. Otherwise, small feedings of a thin formula, or even of water alone, are best until a regular feeding schedule with an adequate formula can safely be instituted.

Vomiting is not uncommon for one or two days after operation. Occasionally it is frequent and lasts for several days, for which there are two possible explanations: (1) The enlarged, irritable stomach is accustomed to emptying itself in this manner. (2) Following pyloromyotomy the mucous membrane and muscularis become swollen and edematous, and it may be some days before the tissues return to their normal state and the stomach can freely empty into the duodenum through the pyloric ring.

In all patients, and particularly those in whom vomiting occurs, the use of parenteral solutions, including blood, is as wise after operation as it is necessary before. My own experience is that when these measures are employed the

operation is attended with little shock, convalescence is smooth, peritoneal infection and wound infection seldom occur, and disruption of the wound is almost never observed.

As far as I know, no abdominal incision precisely similar to the one I have described, for approaching the hypertrophied pylorus, has previously been recorded. Davis,[2] in 1944, proposed a somewhat similar one which, however, included a longitudinal incision of the fibers of the right rectus abdominis muscle.

I believe that the abdominal incision which I have proposed is superior to this incision, as well as to the other incisions ordinarily used (high right rectus, high midline, right subcostal) for the following reasons:

1. Since the approach to the pylorus is by way of the fascia, no muscles are injured.
2. The incision is directly over the prepyloric region of the stomach, which makes it possible to deliver the hypertrophied pylorus into the wound without difficult and traumatic manipulations.
3. Closure is simple, and when it is accomplished there is no tension on the suture lines in the anterior and posterior rectus sheaths, between which the right rectus abdominis muscle lies as a buffer. Dehiscence of the wound is therefore highly unlikely, even if vomiting is persistent.
4. The infant can be placed on the side, if desired, immediately after operation, and in the prone position within a few hours.
5. The minimum trauma produced by the incision favors prompt healing of the wound.

I have deliberately termed the basic operation for infantile pyloric stenosis the Frédet-Weber-Rammstedt operation, although it is usually known merely as the Rammstedt operation, or at most as the Frédet-Rammstedt operation, Weber's contribution being entirely ignored. A note on the evolution of the procedure therefore seems in order.

Pyloroplasty, which was the preferred surgical treatment for infantile pyloric stenosis in the first years of this century, clearly did not solve the problem. Frédet,[3] who performed his first operation Oct. 12, 1907, obviated its two most objectionable features (opening of the infected gastric cavity, which invited peritonitis, and sectioning of the vascular mucosa, which introduced the risk of hemorrhage) by carrying the longitudinal incision only to the mucosa and by not opening the stomach. He sutured the muscularis transversely, but noted that the tension on the muscular layers of the pylorus was so excessive that a diamond-shaped area of mucosa had to be left uncovered.

In Germany, Weber,[4] without knowledge of Frédet's work, used the same technique, on Dec. 3, 1908. Unlike Frédet, who used the procedure only once, he employed it in three patients, in one of whom death occurred from hemorrhage. The operation was severely criticized, and no one else performed it until September, 1911, when Rammstedt[5] performed it, using Weber's technique, without knowledge of Frédet's work.

Rammstedt's patient vomited persistently for several days, after which vomiting abruptly ceased and recovery was smooth. The abrupt turn for the better, he speculated, could be explained only by the giving way of the sutures, which permitted the wound to right its direction, the edges to separate, and the mucosa to protrude. Three months later, in January, 1912, Rammstedt operated for pyloric stenosis by the same technique, but omitting the sutures, and thus the modern operation was born. Incidentally, after Rammstedt's work was popularized, Frédet resumed the operation; in the thirteen years which

had intervened since he first performed it, he had treated infantile pyloric stenosis by gastroenterostomy.

SUMMARY

A transverse abdominal incision for use in the approach to the hypertrophied pylorus in infantile pyloric stenosis is described, and has not, as far as can be determined, been previously described. Certain phases of preoperative and postoperative care which add materially to the safety of the operation are also discussed.

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GANGRENOUS CYSTITIS

ETIOLOGIC CLASSIFICATION AND TREATMENT

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STIRLING and Hopkins,‡ in 1934, reviewed the literature concerning gangrene of the bladder. They found reports of 207 cases, to which they added reports of two cases of their own. Most urologists and pathologists agree that this frequently fatal condition is much more common than the case reports would indicate.

Many etiologic factors have been mentioned in connection with the reports of cases that have appeared in the literature. On the basis of these factors we evolved the classification shown in Table I. A variety of names for the pathologic changes also have appeared in the literature. These include croupous cystitis, diphtheritic cystitis, dissecting gangrenous cystitis, exfoliative cystitis, gangrenous cystitis, membranous cystitis, and pseudomembranous cystitis.

Apparently gangrenous cystitis has been found most frequently in women. In the majority of cases the condition has been thought to be a complication of labor. It is attended by a high mortality. Stirling and Hopkins found that of the 200 cases in which the outcome was known, death had occurred in 120 and recovery in only 80. More recently cases of gangrenous cystitis associated with excessive coagulation after transurethral prostatic operations have been added to the literature.

The clinical picture is most frequently one of severe infection of the urinary tract. The accompanying constitutional reaction is extreme if the process has extended to the kidneys. Boardlike rigidity of the abdomen is evident in those cases in which the peritoneum is involved. Fetid ammoniacal urine containing

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‡Stirling, W. C., and Hopkins, G. A.: Gangrene of the Bladder: Review of Two Hundred Seven Cases; Report of Two Personal Cases, J. Urol. 31: 517-525, 1934.

TABLE I. ETIOLOGY OF GANGRENOUS CYSTITIS*

I. Direct causes: Production of cellular death
  A. Chemical irritation
    1. After instillation of solutions that are too caustic or too acid, intentionally for the treatment of cystitis or accidentally for the induction of abortion
  B. Physical irritation
    1. Secondary to excessive thermal, roentgen, or radium exposures
  C. Infections
    1. Protracted chronic cystitis (frequently associated with vesical overdistention)
    2. Associated with general systemic infections (typhoid, diphtheria, bacillary dysentery, and so forth)

II. Indirect causes: Interference with blood supply and nutrition of bladder
  A. Mechanical closure by pressure, ligature, or overstretching of tissues
    1. Chronic urinary retention with overdistention of the bladder from any cause (impacted vesical or urethral calculi, urethral stricture, ruptured urethra, prostatic hypertrophy, general surgical procedures, and so forth)
    2. Extravesical pressure as from a gravid, impacted uterus or incarcerated uterine myoma, usually associated with vesical overdistention
    3. Circulatory obstruction secondary to a surgical procedure performed on, or adjacent to, the bladder
  B. Injury or disease of the blood vessels
    1. Transurethral operative procedures on the prostate gland
    2. Difficult and prolonged labor
    3. Secondary to severe mechanical trauma of pelvis from without
  C. Thrombosis and embolism
    1. Secondary to causes of injury or disease of the blood vessels previously listed
    2. After roentgen or radium irradiations
    3. Metastatic bacterial emboli
  D. Disturbance due to nerve influences
    1. Cord bladders associated with overdistention and urinary infection.

*General conditions, such as age, diabetes, nephritis, acute disease (typhoid fever), and debility, which are believed to weaken the tissue resistance, promote these causes. The activity of the process can be facilitated further by secondary introduction of bacteria.

much pus, blood, albumin, detritus, and bits of membrane containing vesical tissue is practically diagnostic.

Treatment consists of early and adequate drainage. In men, early suprapubic drainage with removal of the necrotic membrane is advocated by all authors who have discussed treatment for this condition. After recovery, treatment of any lesion which causes interference with the vesical blood supply should be instituted. Occasionally spontaneous cure may take place in women since the urethra is sufficiently ample to permit the passage of necrotic material. However, as illustrated by the accompanying case report, spontaneous extrusion of the necrotic material may result in apparently permanent urinary incontinence.

This case is reported for the following reasons: (1) It represents a case of spontaneous cure; (2) the extruded material is a complete cast of the bladder (Fig. 1); (3) A careful follow-up study reveals that perhaps women as well as men should receive early suprapubic drainage with removal of the necrotic material in the hope of avoiding damage to the external urinary sphincter.

REPORT OF CASE

An unmarried white woman, aged 64 years, was admitted to the Mayo Clinic in August, 1942. She was profoundly dyspneic and gave a history of having suffered from bronchial asthma for the last fifteen years. The asthmatic attacks always had been worse in the winter, but this year the respiratory discomfort had persisted throughout the summer months. She had been hospitalized and a letter from her local physician revealed that she had not responded to the usual forms of treatment. Five other members of her family also suffered from bronchial asthma.

Physical examination revealed a tense and anxious woman who appeared to be suffering from severe respiratory embarrassment. She was well developed and well nourished.

The chest was filled with musical râles but otherwise physical examination revealed no abnormalities. Roentgenogram of the chest revealed bilateral emphysema.

The patient promptly was hospitalized and treated with an oxygen-helium mixture and a variety of antiasthmatic drugs. Despite all therapeutic measures she gradually became comatose and on the second day the outlook was considered to be grave. All laboratory tests were normal except that the concentration of urea was 96 mg. and of sugar was 146 mg. per 100 c.c. of blood, respectively. The urine was free from sugar and contained many casts and no pus cells.

Fig. 1.—Spontaneously extruded cast of bladder and urethra.

The patient could not be aroused on the fourth day in the hospital, but she was moving all extremities and was breathing easier. A neurologic survey including examination of the cerebrospinal fluid and ocular fundi revealed nothing abnormal. Urinary retention developed on the seventh day and catheterization was required until the seventeenth day. During this interval oliguria was present. The urine, which had been free from blood, pus, and organisms, became grossly hemorrhagic on the eleventh day. By this time the patient was completely conscious and was breathing normally. The urinary output returned to normal and the urine became clear on the thirteenth day. By the twentieth day the patient felt so well that she insisted on returning home and was referred to the care of her local physician. At the time of dismissal, she had some urinary frequency. The concentration of blood urea was 58 mg. and the amount of blood sugar was normal. The urine contained many erythrocytes and an occasional pus cell.

The patient returned to the clinic approximately four weeks after dismissal from the hospital and reported that five days previously she had passed a mass of tissue (Fig. 1) through the urethra after three days of intense discomfort in the bladder. Since that experience she had had no control over the excretion of urine, which had continued to be bloody. The expelled mass of tissue, which the patient presented in a bottle, was reported by the pathologists to be "partially necrotic and inflammatory bladder tissue." Careful physical examination was negative. The results of examination of the urine were negative except for many erythrocytes. The concentrations of both the blood sugar and the blood urea were normal. An excretory urogram revealed no abnormalities. Cystoscopic examination under anesthesia induced by intravenous pentothal sodium revealed marked diffuse cystitis with considerable residual old blood remaining in the bladder. All remaining necrotic material was removed from the bladder and a catheter was left in place. Continuous irrigation of the bladder with a solution of sulfanilamide was instituted for several days. When the patient was dismissed on the third day she felt well but still had some urinary incontinence.

In May, 1944, the patient returned for re-examination, at our request. She was evidently in good health and was free from asthma. Although she periodically voided small amounts of urine, she was generally incontinent. The concentration of blood urea was 76 mg. The urine contained many pus cells and an occasional erythrocyte. Culture of the urine revealed *Escherichia coli*. An excretory urogram was unsatisfactory, but it did reveal little or no evidence of function in the right kidney. Cystoscopic examination performed under anesthesia induced by intravenous pentothal sodium demonstrated markedly reduced vesical capacity, grossly normal vesical mucosa, an apparently normal left ureteral orifice, and a markedly shortened urethra. The right ureteral orifice could not be located. The patient was referred to her local physician for irrigations of the bladder and periodic courses of sulfonamide therapy. The abrupt and lasting cessation of bronchial asthma puzzled the internists who examined this patient.

COMMENT

In the past the treatment prescribed for gangrenous cystitis has been dependent on the sex of the patient. Prompt suprapubic drainage with removal of necrotic material was recommended for men. Spontaneous extrusion of necrotic material or removal through the cystoscope was advised for women.

A case of gangrenous cystitis in which the patient had expelled a cast of the bladder through the urethra has been presented. Since this experience resulted in apparently permanent urinary incontinence, early suprapubic drainage for both sexes is recommended.

HUMAN FIBRIN FOAM WITH THROMBIN AS A HEMOSTATIC AGENT IN GENERAL SURGERY

Experimental Studies and Clinical Use

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COMPLETE hemostasis with minimal tissue injury is essential in all branches of surgery. This objective may be attained in many operative procedures by ligature, endothermy, and other methods, but there remain certain situations in which the techniques now available have their shortcomings. It appears, therefore, that in special situations new hemostatic agents may be of value.

The fractionation of human blood plasma in the Department of Physical Chemistry of the Harvard Medical School[1] has provided a method for the preparation of human fibrinogen and thrombin on a large scale.[2] From these proteins, it is possible to prepare a spongy material, fibrin foam,[3] which becomes an effective absorbable hemostatic agent when soaked in human thrombin solution.

Experimental and clinical investigations from the standpoint of the neurosurgeon[4-7] have shown that fibrin foam with thrombin can be used to control bleeding from oozing surfaces, from the dural sinuses, and from large cerebral veins. Furthermore, when it is left in place, it excites a negligible tissue reaction. Studies were at first confined to the central nervous system. The situations in which fibrin foam with thrombin finds its greatest usefulness are most frequent there; furthermore, small amounts of oozing within the closed cranial cavity may be fatal, whereas the loss of the same quantity of blood in other tissues creates only a minor complication of wound healing. On the dura and within the brain substance, previous studies[4-7] have shown that the fibrin foam rapidly becomes more compact and is absorbed with only slight cellular infiltration within a month or less. The final fibrous tissue reaction is so slight that it usually cannot be identified in tissue sections. The final reaction to a large quantity of fibrin foam with thrombin is less than that to a single black silk suture.

There are certain operative procedures in general surgery during which the control of oozing from vessels not suitable for ligature may require a great deal of time or be difficult to effect with conventional techniques. These include the cut surfaces of the liver, kidney, and lung, as well as the abdominal wall, muscles, and peritoneum in certain patients, especially those with jaundice, hemophilia, and bleeding tendencies due to other causes. Fibrin foam with thrombin has been used under all these conditions and has been found speedily effective in controlling capillary and venous bleeding. While many studies of the tissue reactions to fibrin foam with thrombin in the central nervous system

This work has been carried out under contract recommended by the Committee on Medical Research between the Office of Scientific Research and Development and Harvard University.

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have been carried out, we have regarded investigations in other organs and comparison with various absorbable hemostatic agents as essential before recommending clinical use of fibrin foam with thrombin in general surgery. It is the purpose of this report to describe these experiments and to discuss experiences with the clinical use of fibrin foam with thrombin in general surgery.

EXPERIMENTAL STUDIES

Fibrin Foam With Thrombin in the Liver

Circumstances requiring an absorbable hemostatic agent in general surgery are frequently encountered in dealing with hepatic lacerations, tumors, or other lesions for which the liver parenchyma is incised. Experiments to determine the

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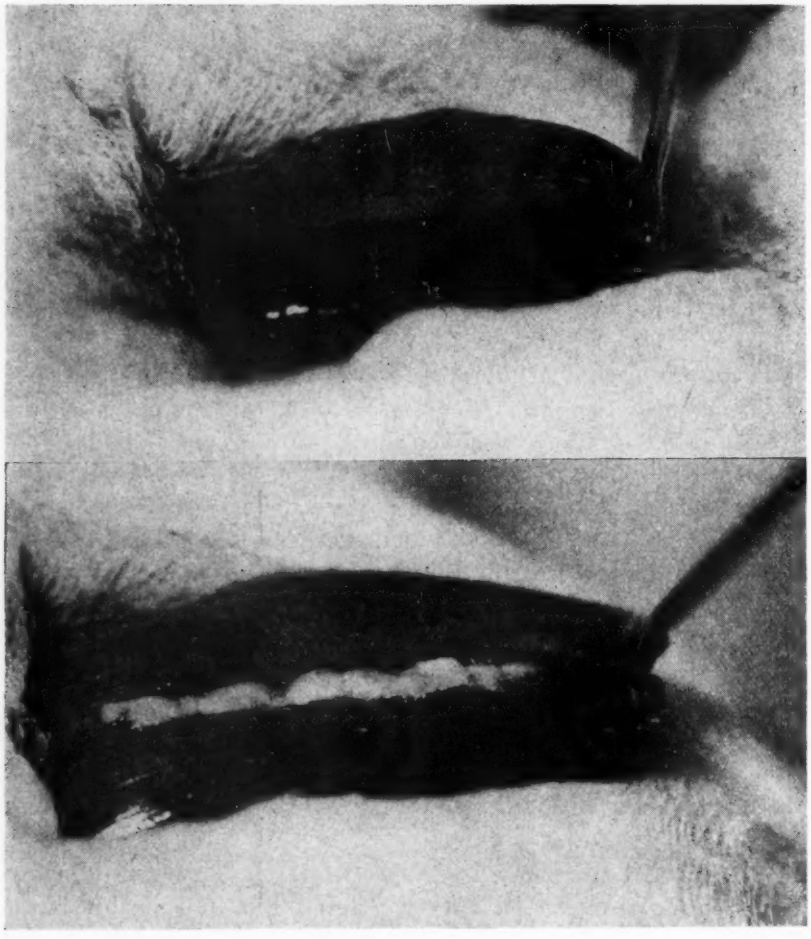


B.

Fig. 1.—Procedure 1. Experimental laceration of the liver, showing: *A*, free bleeding before the application of fibrin foam with thrombin; *B*, hemostasis resulting from the use of fibrin foam with thrombin.

tissue reactions to human fibrin foam with thrombin were therefore carried out in animals and these reactions compared with those excited by various other hemostatic agents. All experiments were carried out under nembutal anesthesia unless otherwise stated. Sections for histologic study were stained with phloxine and methylene blue after fixation in acetic Zenker's solution.

Procedure 1.—The left lobe of the liver was delivered into a laparotomy wound, so that about 3 cm. of its surface was exposed. A scalpel was plunged

into the liver to a depth of 2 cm. and drawn through the liver substance for approximately 4 cm. The laceration of the liver was then packed with fibrin foam with thrombin. One or two mattress sutures of black silk were placed in the liver capsule to close the laceration. Effective hemostasis was secured (Fig. 1). This procedure was carried out in five monkeys, which were autopsied at the following intervals after operation: 30 minutes, 4 hours, 21, 70, and 74 days.

Pathologic studies: Sections of unimplanted fibrin foam, sectioned for comparison (Fig. 2), were composed of meshes of fibrin which stained deep blue with the phloxine-methylene blue technique. These represented cross sections of the honeycomb-like spaces in the fibrin foam. In the specimen obtained 30 minutes after operation (Fig. 3) the fibers of the fibrin foam were little changed from those of the control specimen. Some of the spaces were filled with well-formed blood clot, indicating that blood oozing into the center of the mass

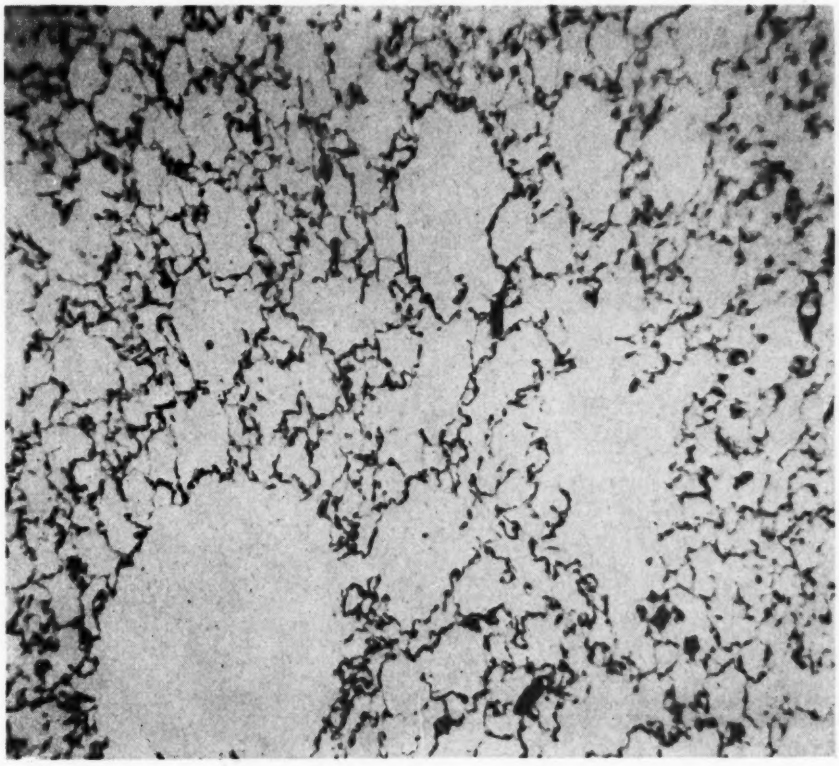


Fig. 2.—Histologic appearance of fibrin foam before implantation. (Phloxine methylene blue stain, ×54.)

of fibrin foam was promptly coagulated. There were no leucocytes within the substance of the material but a few groups of leucocytes were present at the line of incision. These were probably due to the trauma of the operation rather than to the presence of the fibrin foam, since they were found only along the line of incision. Adjacent liver cords were somewhat compressed but were otherwise normal.

At 4 hours, the fibrin foam had decreased markedly in volume. The meshes were much smaller (Fig. 4) and the fibers in most places took the phloxine stain, although some of them at the center still stained with methylene blue. The blood clot in the interstices was still present and a very few polymorphonuclear leucocytes had made their appearance within the meshes of the fibrin foam. In some areas, both at the center and adjacent to the liver tissues, considerable

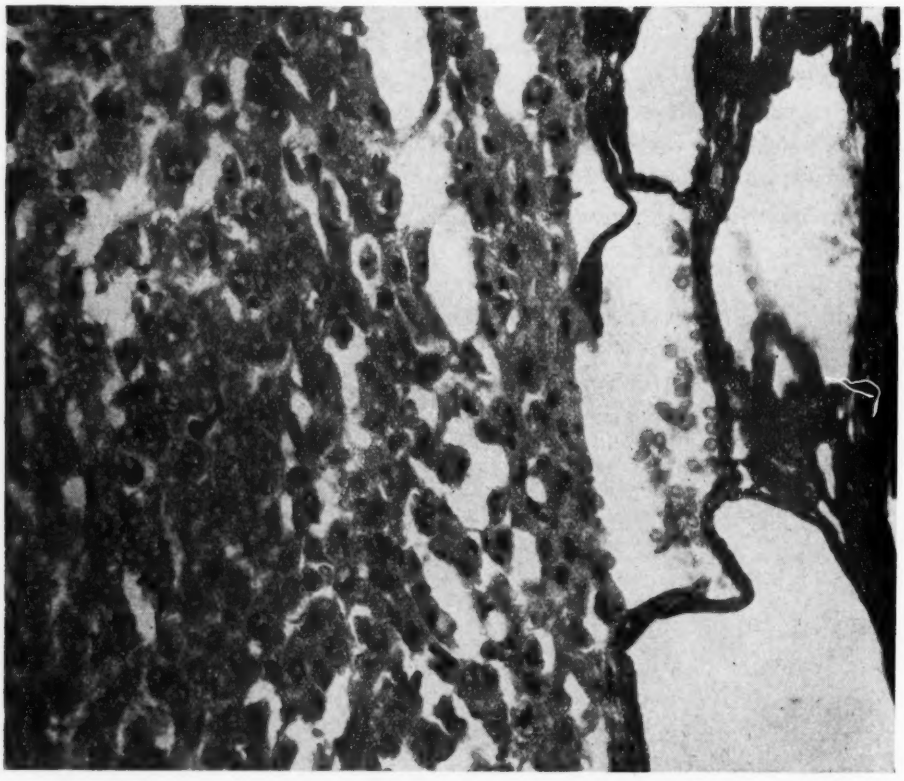


Fig. 3.—Procedure 1. The monkey had been sacrificed 30 minutes after the application of fibrin foam with thrombin to an experimental laceration of the liver. The meshes of the fibrin foam are beginning to become smaller; they contain some red blood cells. The adjacent cells of the liver parenchyma are pyknotic and somewhat fragmented as the result of the operative procedure. At this stage there is no inflammatory cellular infiltration in response to the fibrin foam with thrombin. (Phloxine methylene blue stain, ×300.)

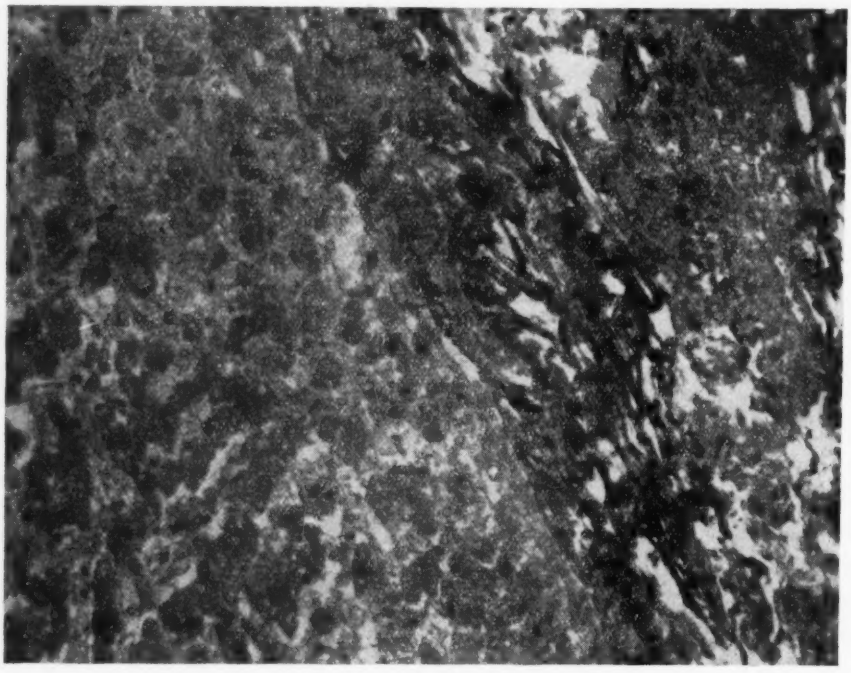


Fig. 4.—Procedure 1. The monkey had been sacrificed 4 hours after the application of fibrin foam with thrombin to an experimental laceration of the liver. The meshes of the fibrin foam are much smaller than at 30 minutes after application. They contain clotted blood. Note the absence of inflammatory cellular reaction to the fibrin foam at this stage. (Phloxine methylene blue stain, ×300.)

liquefaction of the fibrin foam had occurred, the spaces being occupied in sections by a phloxine-staining precipitate. This process was not accompanied by leucocytic infiltration.

At 21 days after operation, a small mass of fibrin foam was still demonstrable (Fig. 5). This was compact and showed little evidence of the original honeycomb structure. The fibers were swollen and took the phloxine stain. About the periphery, there was a small amount of fibrous tissue proliferation with slight infiltration by mononuclear cells and lymphocytes. A few giant cells were present.

In the animals sacrificed at 70 and 74 days no traces of fibrin foam were found. The wounds had healed with the formation of a cicatrix which did not seem larger or different in character from scars in which no fibrin foam had been used (Fig. 6). Conspicuous tissue reaction with giant-cell formation was found about the black silk sutures.

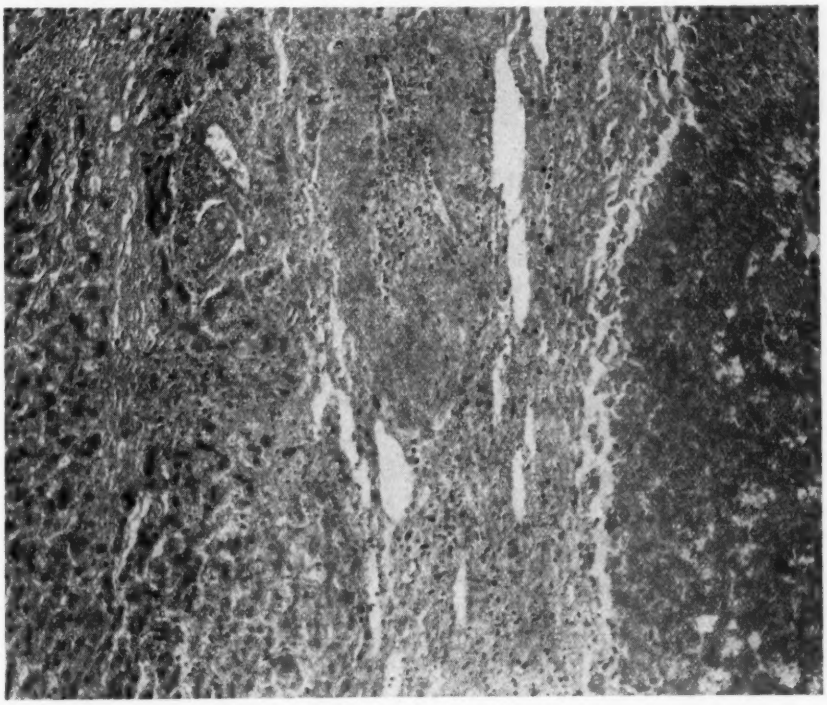


Fig. 5.—Procedure 1. The monkey had been sacrificed 21 days after the application of fibrin foam with thrombin to an experimental laceration of the liver. At the right of the photomicrograph, there is a small compact mass of fibrin foam not yet absorbed. Scar tissue is forming at the center. (Phloxine methylene blue stain, ×110.)

Result: Fibrin foam with thrombin satisfactorily controlled bleeding from experimental liver lacerations in five monkeys. Tissue reaction was minimal, the hemostatic material being almost completely absorbed in 21 days and entirely so at 70 days. The amount and character of the scar tissue was not demonstrably altered by the use of fibrin foam with thrombin.

Procedure 2.—A stab wound was made in the liver and a cube of fibrin foam 1 by 1 by 1 cm., soaked in human thrombin solution, was inserted 1 cm. below the surface of the liver. The wound was closed with one black silk suture to serve as a marker. A cube of soluble cellulose of the same size and also soaked in human thrombin solution was inserted at a similar depth below the capsule of a different portion of the liver. This procedure was carried out in five monkeys, which were sacrificed at the following intervals after operation: 11 and 16 days, 8½ and 12 weeks.

Pathologic studies: At 11 days, the fibrin foam had been absorbed save for a few fragments. The fibers were clumped in small groups and the original honeycomb structure had disappeared. At the centers of the fibers of residual fibrin foam, the material was deep blue, while it was stained with phloxine where it came in contact with the tissue. These remnants were surrounded by moderate numbers of polymorphonuclear leucocytes, mononuclear cells, and a few lymphocytes. Giant cells were found about some of the smallest fragments. The amount of soluble cellulose remaining was approximately the same as that of fibrin foam.

Fig. 6.—Procedure 1. The monkey had been sacrificed 70 days after the application of fibrin foam with thrombin to an experimental laceration of the liver. The fibrin foam has been completely absorbed and there are no characteristics of the scar which can be correlated with the use of this hemostatic agent. (Phloxine methylene blue stain, ×200.)

In the specimen obtained at 16 days, the amount of fibrin foam remaining was similar to that found at 11 days. Fibrillar structure was no longer apparent, the fragments being homogeneous and staining entirely with phloxine. Giant cells were more numerous while polymorphonuclear leucocytes had almost disappeared and had been replaced by mononuclear cells. Proliferation of connective tissue was present about the fragments of fibrin foam, blending with the rest of the scar tissue. Only minute fragments of the soluble cellulose were found. The region in which it had been implanted was occupied by a mass of giant cells, often containing bits of the soluble cellulose, together with moderate numbers of mononuclear cells and a few polymorphonuclear leucocytes. There was proliferation of connective tissue in the region. How much of this was due to the soluble cellulose and how much to the healing of the incision per se could not be determined.

No traces of fibrin foam or of soluble cellulose were found in the animals sacrificed 5, 8½, or 12 weeks after operation. In all instances, the incisions were well healed by compact cicatrices containing no elements which could be related definitely to implantation of either type of hemostatic material.

Result: When embedded in the liver of monkeys, fibrin foam with thrombin and soluble cellulose with thrombin were absorbed at the same rate. Both caused tissue reaction of about the same amount and character.

Procedure 3.—Procedure 2 was repeated with the variation that sulfadiazine was used in conjunction with the hemostatic materials. The pieces of fibrin foam and of soluble cellulose were soaked in thrombin, taken from the solution, rolled in sulfadiazine powder, and then placed in the incision in the liver. Procedure 3 was carried out in five monkeys, which were autopsied at the following intervals after operation: 8 days, 5½, 8, 9, and 12 weeks.

Pathologic studies: At 8 days, a portion of fibrin foam 6 by 5 mm. remained. While the fibrin foam was more compact than unimplanted material, the meshes were still present and were filled with blood clot, which was disintegrating. No giant cells and very few polymorphonuclear leucocytes were seen at the periphery. Little proliferation of connective tissue was seen. The pieces of soluble cellulose measured 3 by 7 mm. The tissue reaction to the soluble cellulose was almost identical with that induced by the fibrin foam.

In the animals sacrificed at 5½, 8, 9, and 12 weeks, the incisions in the liver were entirely healed. No fibrin foam or soluble cellulose could be made out. There were no residua in the scar which could be correlated with the implantation of either hemostatic agent or with the use of sulfadiazine.

Result: When fibrin foam with thrombin was rolled in sulfadiazine powder and implanted in the liver, the tissue reactions and absorption of the materials were identical with those found when no sulfadiazine was used. The same was true when sulfadiazine was used with soluble cellulose.

Procedure 4.—After a small midline abdominal incision had been made, a cube of fibrin foam with thrombin 0.7 cm. in each dimension was placed between the traumatized liver and the diaphragm. In another area, a piece of soluble cellulose of the same size was placed between the liver capsule and the diaphragm. The abdominal incision was closed in layers. This procedure was carried out in five monkeys, which were autopsied at 3 (2 animals), 4½, 8, and 12 weeks.

Pathologic studies: In the monkeys examined at 3 weeks, definite remnants of fibrin foam and of soluble cellulose were found on the surface of the liver but in neither case were they adherent to the diaphragm. The residual fibrin foam was more compact than unimplanted fibrin foam but its meshlike character was preserved throughout. There was a thin but complete fibrous tissue capsule about the fragment. At the margin between the fibrous tissue and the fibrin foam, as well as within the fibrous tissue, there were considerable numbers of mononuclear cells, some lymphocytes, and a very few polymorphonuclear leucocytes. The most conspicuous feature of the tissue reaction, however, was the presence of a line of giant cells about the fibrin foam at the periphery of the mass. The giant cells formed a layer one giant cell deep about the portion of the fibrin foam in contact with the superior surface of the liver but were almost entirely absent on the surface toward the diaphragm. Only a few giant cells were seen within the deeper portions of the fibrous tissue. No adhesions were found between the fragment and the diaphragm, the fibrin foam having become adherent only to the liver. Less residual soluble cellulose was recovered than fibrin foam in these specimens. The tissue reaction to it, however, had many points of similarity. Residual soluble cellulose was found adherent to the liver but not to the diaphragm. About the material was a layer of fibrous tissue somewhat wider than that surrounding the fibrin foam. The center was com-

posed of bits of soluble cellulose, usually surrounded by giant cells without demonstrable soluble cellulose fragments, numerous large mononuclear cells, a few lymphocytes, and very rare polymorphonuclear leucocytes.

At 4½ weeks, no fibrin foam could be identified. In the place where it had been put, the liver capsule was very slightly thicker than elsewhere, the thickening being due to an increase in fibrous tissue. The soluble cellulose was also entirely absorbed. There was the same fibrous tissue thickening of the capsule as with fibrin foam, although it was slightly greater in the case of the soluble cellulose. At one point there were a few lymphocytes and a small group of giant cells within the fibrous tissue. No adhesions to the diaphragm had formed.

In the monkeys examined 8 weeks after operation, the only means of identifying the region in which fibrin foam had been placed was a slight fibrous thickening at one point. One very small adhesion to the diaphragm was noted. There was a similar thickening of the capsule without diaphragmatic adhesion in the region where soluble cellulose had been placed. A very small group of giant cells and lymphocytes was seen in the fibrous tissue.

No traces of fibrin foam, soluble cellulose, or reaction to these materials could be identified 12 weeks after operation.

Result: When fibrin foam was placed between the liver and diaphragm, a foreign body reaction was elicited which was much less extensive, however, than the reaction to a single black silk suture. This subsided quickly, leaving only a very slight thickening of the liver capsule with one adhesion to the diaphragm. The behavior of soluble cellulose was very similar, although the main mass was absorbed somewhat more rapidly than was that with fibrin foam. However, signs of cellular activity persisted longer with soluble cellulose than with fibrin foam.

Procedure 5.—Procedure 4 was repeated with the variation that the fibrin foam and soluble cellulose, after soaking in thrombin, were rolled in sulfadiazine powder. Procedure 5 was carried out in five monkeys which were autopsied at the following intervals after operation: 5½, 8 (two animals), 8½, and 12 weeks.

Pathologic studies: At 5½ weeks the fibrin foam was completely absorbed with only traces of fibrous tissue thickening of the liver capsule and no diaphragmatic adhesions. The soluble cellulose was also completely absorbed, its site being marked by a group of giant cells and lymphocytes as well as a small adhesion to the diaphragm.

At 8 weeks and at 8½ weeks no trace of fibrin foam or soluble cellulose could be found and the areas in which they had been placed showed no adhesions.

In the monkey sacrificed 12 weeks after operation, there was a small adhesion in the region where fibrin foam had been left, but none in the place where soluble cellulose had been inserted.

Result: The simultaneous use of sulfadiazine with fibrin foam with thrombin and soluble cellulose with thrombin did not prevent the absorption of these materials or alter the final result significantly.

Procedure 6.—A stab wound 1 cm. deep was made in the left lobe of the liver (as in Procedure 2) in which was placed a piece of fibrin foam 1 by 1 by 1 cm. soaked in thrombin. The same amount of fibrin foam with thrombin was dipped in a solution of penicillin. This was then similarly implanted in a different area of the left hepatic lobe. Procedure 6 was carried out in one monkey, which was sacrificed 34 days after operation.

Pathologic studies: The fibrin foam with thrombin without penicillin was largely absorbed although a small area of residual fibrin foam was still present.

This was surrounded by the fibrous tissue of the scar closing the line of incision. Giant cells were very rare and infiltration with mononuclear cells and lymphocytes was slight. Sections of the area in which penicillin-soaked fibrin foam with thrombin had been placed showed the same histologic appearance.

Result: In one monkey, the use of penicillin solution at the same time as fibrin foam with thrombin resulted in tissue reactions identical with those to fibrin foam with thrombin in the absence of penicillin.

Procedure 7.—A stab wound 1 cm. deep was made in the left lobe of the liver (as in Procedure 2). A piece of fibrin foam 1 by 1 by 1 cm. was soaked in thrombin and inserted in the stab wound. In another portion of the left lobe, a piece of monkey's rectus muscle 1 by 1 by 1 cm. (not soaked in thrombin) was similarly implanted. Procedure 7 was carried out in three monkeys, which were sacrificed 3, 7, and 14 days after operation.

Pathologic studies: At 3 days, the piece of fibrin foam measured 4 by 3 mm. It was composed of meshes of deep blue-staining material, the interstices containing blood clot near the liver tissue and appearing empty at the center. A few scattered polymorphonuclear leucocytes, mononuclear leucocytes, and lymphocytes were present in the adjacent liver tissue but reaction to the fibrin foam was very slight. Giant cells were not encountered. The muscle fragment measured 7 by 3 mm. The general histologic features of the muscle were clearly visible, although disintegration had begun. About the fragment was some blood clot. Within the adjacent liver tissue, polymorphonuclear leucocytes were numerous and a few mononuclear cells and lymphocytes were also seen. Similar cells in moderate numbers were found scattered through all parts of the muscle implant. A small group of giant cells was seen in one area.

In the monkey sacrificed at 7 days, the remnant of fibrin foam measured 3 by 3 mm. Polymorphonuclear leucocytes were very rare but mononuclear cells and lymphocytes were somewhat more numerous than in the specimen at 3 days. There was some proliferation of fibroblasts about the fibrin foam. A small number of giant cells had become isolated from the main mass. The muscle fragment measured 7 by 3 mm. Disintegration of muscle fibers had progressed much further than at 3 days. There was partial replacement of the fragment by fibrous tissue. Polymorphonuclear leucocytes were few, but scattered lymphocytes and mononuclear cells were found in moderate numbers both within the muscle fragment and at its periphery. Giant cells were present in small numbers.

At 14 days, the remaining fibrin foam measured 3 by 3 mm. The fibers had become more compact but the netlike character was clearly shown. The periphery of the fragment was surrounded by numerous giant cells, lymphocytes, mononuclears, and a few polymorphonuclear leucocytes. There was some proliferation of connective tissue about the fibrin foam. The muscle fragment measured 6 by 4 mm. Further stages of the process outlined at 7 days were found in this specimen. Many partially disintegrated muscle fibers were seen; fibrous tissue surrounded the fragment and was replacing the muscle fibers. Giant cells were occasionally encountered. About the fragment, lymphocytes and mononuclear cells were numerous, while polymorphonuclear leucocytes were few; only scattered cells of these types were found within the fragment itself.

Result: The tissue reaction to muscle in the liver was much greater than the reaction to fibrin foam with thrombin. Fibrin foam with thrombin tended to be removed with relatively mild reaction while muscle tended to be replaced by fibrous tissue.

Procedure 8.—The liver was exposed as in the other procedures. A piece of fibrin film 2 by 2 cm. square was placed on the diaphragmatic surface of the liver, being held there by black silk sutures at each corner. At the same time, a cube of fibrin foam with thrombin, 0.8 cm. on each side, was placed between the film and the liver capsule. This procedure was carried out in two monkeys, one being sacrificed 107 days and the other 154 days after operation.

Pathologic studies: At 107 days, the fibrin foam with thrombin and the fibrin film had been completely absorbed. There were a few scattered lymphocytes and mononuclear cells in the region but giant cells were not found. The fibrin film had been replaced by fibrous tissue, which was much less in amount than the original fibrin film. This fibrous tissue was dense at the periphery and very vascular at the center. The adjacent portions of the liver capsule were slightly thickened, owing to increase in connective tissue. There were a few delicate adhesions between the diaphragm and the liver capsule in this region.

One hundred fifty-four days after operation neither fibrin foam with thrombin nor fibrin film could be identified. The site of operation could be located only by the presence of the black silk sutures. No adhesions or detectable thickening of the liver capsule was found.

Result: The simultaneous use of fibrin foam with thrombin and fibrin film did not prevent the absorption of both or alter the final reactions to either.

Fibrin Foam With Thrombin in the Peritoneal Cavity

If fibrin foam with thrombin is to be used as a hemostatic agent in abdominal surgery, it is important to determine to what extent the material is a peritoneal irritant, whether it is absorbed in the peritoneal cavity, and whether its presence leads to the formation of adhesions. Opportunities for controlled study of these questions in the clinic are very few. Accordingly, a series of experiments was set up in monkeys to test these possibilities.

Procedure 9.—A piece of fibrin foam with thrombin, measuring 0.8 cm. on each side, was placed on the surface of the pelvic peritoneum to the left of the uterus and a piece of soluble cellulose with thrombin of the same size was placed to the right of the uterus. This procedure was carried out in five monkeys which were sacrificed 5, 8, 8½, and 12 weeks after operation.

Pathologic studies: In the monkeys sacrificed at 5, 8, 8½, and 9 weeks, no adhesions were found and no traces of fibrin foam or soluble cellulose could be made out. Since no sutures had been used to mark the place where the materials had been left on the surface of the peritoneum, the sites could not be identified with certainty. The entire surface of the pelvic peritoneum was uniformly smooth and glistening. When the monkey was examined at 12 weeks after operation, no residual fibrin foam or soluble cellulose was found. There were no adhesions where soluble cellulose had been left but a few fine adhesions were seen in the region of the pelvic peritoneum where fibrin foam had been placed. Histologic sections showed these adhesions to be richly vascular. About them on the surface of the pelvic peritoneum was a reaction to cotton fibers, evidently from the surface of the sponge placed in the pelvis during operation. There was no evidence that the adhesions were due to the fibrin foam.

Result: At 5 weeks and later, both fibrin foam with thrombin and soluble cellulose with thrombin had been absorbed from the pelvic peritoneum without demonstrable residual reaction.

Procedure 10.—Procedure 9 was repeated with the variation of sulfadiazine being employed in conjunction with both the hemostatic materials. Pieces of fibrin foam and of soluble cellulose were soaked in thrombin, taken from the

solution, rolled in sulfadiazine powder, then placed on the pelvic peritoneum as in Procedure 9. Procedure 10 was carried out in five monkeys which were autopsied 5, 8, 8½, 9, and 12 weeks after operation.

Pathologic studies: At 5 weeks, fine adhesions were found about the sites where both fibrin foam and soluble cellulose were left. Histologic studies showed that these adhesions were formed about fibers of cotton, as in one monkey in Procedure 9. No remnants of fibrin foam or of soluble cellulose were seen. In the monkeys autopsied at 8, 8½, 9, and 12 weeks after operation, no residual fibrin foam or soluble cellulose was encountered. There were no adhesions and the pelvic peritoneum was smooth and glistening throughout.

Result: The use of sulfadiazine with fibrin foam and with soluble cellulose did not prevent the absorption of either hemostatic agent and did not lead to the formation of adhesions.

Fibrin Foam With Thrombin in the Abdominal Wall

Ordinarily, fibrin foam with thrombin would not be needed in the abdominal wall, where the bleeding is satisfactorily and expeditiously controlled with ligature. However, in patients with jaundice, hemophilia, and a few other conditions, there is troublesome oozing from large surfaces on which conventional methods of hemostasis are ineffective. On such surfaces a coating of fibrin foam with thrombin might be useful. Since the tissue reactions to fibrin foam with thrombin are minimal in regions such as the brain, liver, and peritoneum, it would not be expected that they would be significant in the abdominal wall. However, a few studies were carried out in guinea pigs to test this point.

Procedure 11.—Guinea pigs weighing about 350 grams were anesthetized with ether. Two incisions 0.7 cm. long were made in the abdominal skin, one on each side of the midline. Dissection was carried out laterally along the superficial fascia for 2 to 3 cm. Cubes of fibrin foam with thrombin 0.5 cm. on each side were placed as far laterally as possible. The incisions were closed with a single black silk suture. This procedure was carried out in 3 guinea pigs, which were sacrificed at 3, 7, and 14 days after operation.

Pathologic studies: In the specimen obtained 3 days after operation, the fragment of fibrin foam measured 0.5 by 0.2. Its meshes were smaller than those of unimplanted fibrin foam. The centers of the fibers retained the methylene blue, while the edges were stained with phloxine. Polymorphonuclear leucocytes were scattered in small numbers through the meshes of the fibrin foam and were somewhat more numerous at the periphery. No giant cells were seen and very little cellular infiltration was found outside the fragment of fibrin foam, other than that accounted for by the trauma of inserting the material. At 7 days the residual fragment measured 0.3 by 0.2 cm. The fibers were being broken up and more of them took the phloxine stain. Considerable infiltration with lymphocytes and mononuclear cells as well as a few polymorphonuclear leucocytes was present together with some connective tissue proliferation about the fragment. There were no giant cells. In the guinea pig sacrificed at 14 days, no fibrin foam was seen grossly, although a few isolated bits of fibers could be made out on microscopic study. The infiltration with lymphocytes and mononuclear cells was less than at 7 days and the area about the original site contained connective tissue which was more compact than in the preceding specimen.

Result: In three experiments, the absorption and tissue reaction to fibrin foam with thrombin were similar to those described in the liver, central nervous system, and elsewhere.

A large series of experiments was carried out in the abdominal wall by this technique to test differences in tissue reaction when the conditions varied under which the fibrin foam was manufactured. These all led to essentially similar results. Only those experiments carried out with the type of fibrin foam with thrombin now used in the clinic have been reported in this paper. However, the other experiments lend support to the conclusion that fibrin foam with thrombin is quickly absorbed from the abdominal wall with no definite increase in scar tissue over that of a simple incision in this area.

Fibrin Foam With Thrombin in the Kidney

In partial resection of the kidney and in nephrotomy, an actively oozing surface is exposed. Hemostasis by means of sutures and other conventional techniques is difficult and often unsatisfactory. Experiments were carried out to determine the effectiveness of fibrin foam with thrombin and to ascertain the tissue reactions in this situation.

Procedure 12.—A lumbar incision was made and the kidney exposed. The capsule was stripped from one pole of the kidney. The pole was then resected, leaving a freely bleeding surface. Fibrin foam with thrombin was placed over the surface, resulting in complete hemostasis. The capsule was sutured over the fibrin foam with thrombin and the wound closed in layers. Procedure 12 was carried out in two monkeys. One died on the twenty-first postoperative day. The other was sacrificed 65 days after operation.

Pathologic studies: The monkey autopsied 21 days after operation had an extensive perirenal abscess which was judged to be the cause of death. Fibrin foam was still present in moderate amount with tissue reaction identical with that described in the liver. At 65 days after operation, the fibrin foam had been completely absorbed. The fibrous tissue of the scar was not larger in amount or different in character from that expected in the healing of a similar wound without fibrin foam.

Result: Fibrin foam with thrombin was effective in controlling the bleeding in resection of the pole of the kidney and was absorbed with negligible tissue reaction.

Procedure 13.—A lumbar incision was made and the kidney delivered into the wound. The renal vessels were compressed with the operator's fingers while a sagittal incision was made in the kidney deep enough to open the renal pelvis. The bleeding surfaces were covered with fibrin foam with thrombin and the capsule of the kidney closed with black silk sutures (Fig. 7). No ligatures were used on the incised surfaces of the renal parenchyma, even on the actively bleeding arteries, since fibrin foam with thrombin brought about complete hemostasis. The capsule was sutured, however. This procedure was carried out in four monkeys, which were sacrificed 3, 7, 10, and 14 days after operation and in one cat, which was sacrificed at 322 days.

Pathologic studies: In the monkey sacrificed at 3 days, there were about 3 c.c. of dark red fluid about the kidney, which was loosely adherent to the perirenal tissue along the suture line. Histologic study showed that the interstices of the fibrin foam were filled with blood clot. At the periphery of the fibrin foam, there was moderate infiltration of polymorphonuclear leucocytes with a few lymphocytes and mononuclear cells (Fig. 8).

In the specimens at 7, 10, and 14 days there was no fluid at the operative site. The suture line was progressively more adherent to the perirenal tissues. Fibrin foam persisted in all three specimens, but decreased in amount as the

time since operation lengthened. The tissue sequences in response to the fibrin foam were the same as those described in the liver. Occasional giant cells were found in the specimen at 7 days; they were numerous at 10 days and were less at 14 days, at which time a large part of the fibrin foam had been absorbed. In the cat sacrificed 322 days after operation, the kidney was not abnormally adherent to the perirenal tissues. The kidney which had been incised was slightly smaller than the opposite kidney. The scar of pyelonephrotomy was identified as a thin white line, not differing grossly or microscopically from the scar of a similar incision in which fibrin foam with thrombin had not been used.

A.

B.

Fig. 7.—Procedure 13. *A,* Free bleeding from the surface of the kidney incised in the sagittal plane. *B,* Complete hemostasis after application of fibrin foam with thrombin. The capsule has been sutured but hemostasis was complete before doing so.

Result: Fibrin foam with thrombin was effective as a hemostatic agent in experimental renal resection and pyelonephrotomy and was absorbed with slight tissue reaction.

Fibrin Foam With Thrombin in the Lung

There are occasions in thoracic surgery, notably in dealing with the lung parenchyma, when capillary and venous bleeding is difficult to control by the conventional methods of hemostasis. Experiments were set up to test the efficacy of fibrin foam with thrombin as a hemostatic agent in the lung and the tissue reactions induced by it in that location.

Procedure 14.—The operations were carried out under nembutal anesthesia; the animals were intubated so that oxygen and carbon dioxide under positive pressure could be used when necessary. The right thoracic cavity was opened in the seventh interspace. After drawing the right lower lobe of the lung into the wound, an incision was made 1.5 cm. long, care being taken to avoid the larger bronchi. A piece of fibrin foam with thrombin 1.5 by 0.7 by 0.5 cm. was placed in the wound, which was closed with one or two black silk sutures. Effective hemostasis was secured in all animals (Fig. 9). The thoracic cavity was closed in layers, all air being aspirated and the lung reinflated with positive pressure. This procedure was carried out in five monkeys. One of these died 5 minutes after operation and the others were sacrificed at 7, 10, 14, and 24 days. It was also performed on a cat, sacrificed at 356 days after operation.

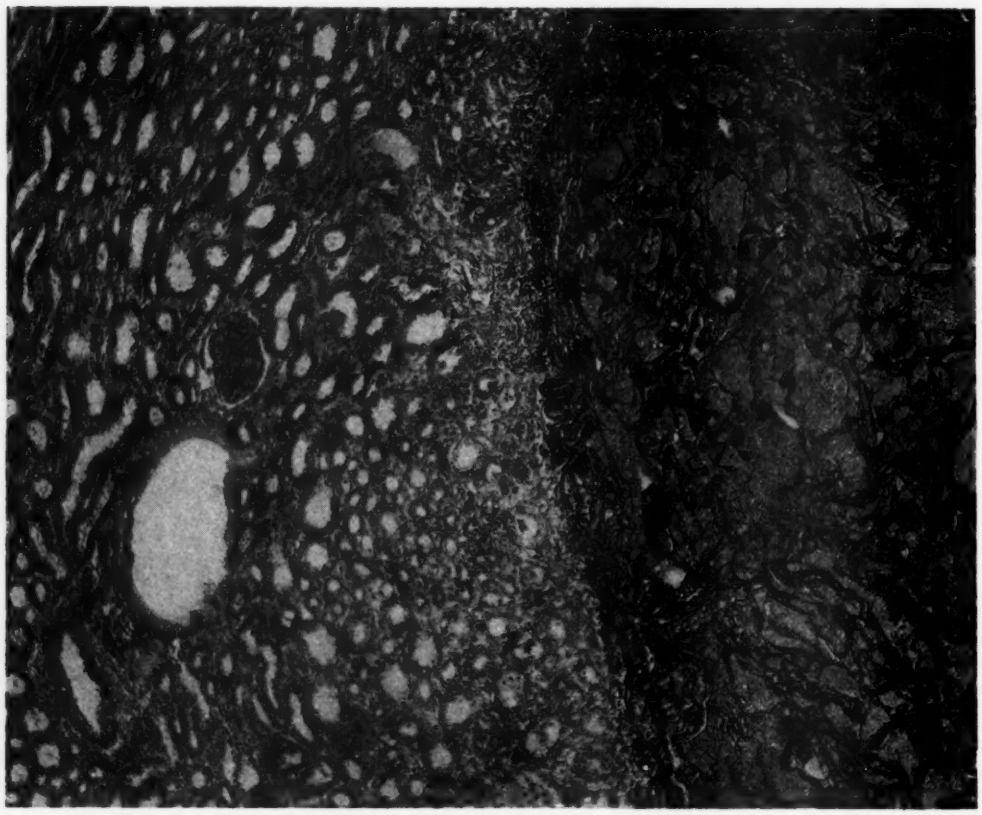


Fig. 8.—Procedure 13. The appearance of fibrin foam 3 days after its application as a hemostatic agent in experimental pyelonephrotomy. (Phloxine methylene blue stain, ×96.)

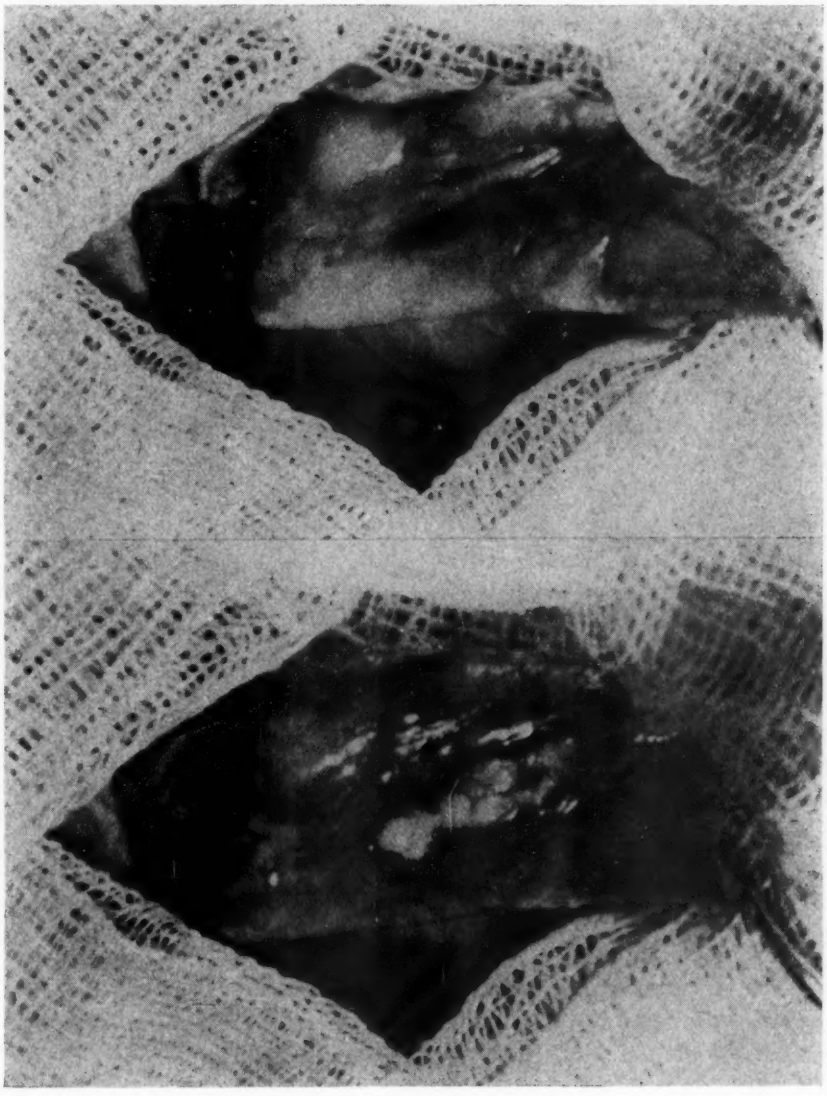
Pathologic studies: In the specimen 5 minutes after operation, the fibrin foam was unchanged in general structure from the unimplanted material. Some of its interstices were filled with fresh blood clot; there was no demonstrable reaction in the surrounding tissue. At 7 days, the fibrin foam was more compact than when implanted. A mild infiltration with polymorphonuclear leucocytes, and a few mononuclear cells and lymphocytes, were seen about it; occasional giant cells were present. Ten days after operation (Fig. 10) the number of giant cells had increased, while at 14 days they were less numerous than at 10 days. Fibrous tissue reaction was slight. In the cat sacrificed at 356 days, the well-healed scar was not adherent to the parietal pleura. It contained no fibrin foam and showed no characteristics which could be correlated with the use of this material at the time of operation.

Result: Bleeding from experimental incisions in the lung parenchyma was controlled by the application of fibrin foam with thrombin. The tissue reactions to the hemostatic material were mild.

COMMENT

These studies have shown that fibrin foam with thrombin is an effective hemostatic agent in the liver, peritoneal cavity, abdominal wall, kidney, and lung of experimental animals. Only a slight tissue reaction is elicited and, in the end result, the amount of fibrous tissue due to the presence of the fibrin foam

A.



B.

Fig. 9.—Procedure 14. *A*, Experimental incision in the lung. *B*, Hemostasis secured by packing the incision in the lung with fibrin foam with thrombin.

with thrombin is so small that it cannot be regarded as clinically significant even when a large mass of fibrin foam with thrombin is used. The fibrin foam with thrombin is completely absorbed in about 5 weeks and sometimes at a shorter interval after implantation. The tissue reaction is not altered by the

use of sulfadiazine or penicillin at the same time. The use of fibrin film and fibrin foam with thrombin does not alter the tissue reaction and final results to either.

Fibrin foam with thrombin elicited very much less tissue reaction than muscle fragments of the same size. The tissue reaction to soluble cellulose with thrombin and fibrin foam with thrombin are about the same qualitatively and quantitatively. The choice between these two substances must be made on the basis of operative convenience rather than upon the extent of tissue reaction. The present studies of this tissue reaction to soluble cellulose are in complete agreement with Frantz.[8] The material used by us was the earlier type of Frantz, designed to be soaked in thrombin; no experiments with her newer type[9] are included in this report. It is difficult to evaluate the significance of

Fig. 10.—Procedure 14. The appearance of fibrin foam 10 days after its application as a hemostatic agent in an incision in the lung parenchyma. (Phloxine methylene blue stain, ×96.)

a few adhesions described both to fibrin foam with thrombin and to soluble cellulose. The mere procedure of exposing the liver often results in the formation of an equivalent amount of adhesions and sometimes more than is seen in this series of animals. In some instances, the adhesions could be shown to be due to cotton fibers, presumably from the gauze used at operation; in others, they could not. Such findings, however, emphasize the safety of fibrin foam with thrombin for they indicate that a large mass of fibrin foam with thrombin leaves less reaction than a group of cotton fibers so small and so few as to be overlooked by the surgeon.

On the basis of this experimental work, fibrin foam with thrombin was recommended for clinical trial in general surgery.

CLINICAL STUDIES

Fibrin foam with thrombin was used first in general surgery at The Children's Hospital and the Peter Bent Brigham Hospital, Boston, Mass. It was then released to several surgical clinics throughout the country. Reports of the use of fibrin foam with thrombin in various operations of general surgery and the surgical specialties other than neurosurgery and dental surgery now number 240. This discussion is based on the reports from these clinics as well as on our own experience.

To date, fibrin foam with thrombin has been used oftener in the liver and biliary passages than elsewhere in general surgery because of the frequency with which oozing surfaces, difficult to control by conventional methods of hemostasis, are encountered in these locations. Bleeding from the bed of the gall bladder during cholecystectomy is at times troublesome. Fibrin foam with thrombin quickly and effectively controls the capillary bleeding, thus decreasing blood loss, reducing the length of the operation, and sometimes allowing closure without drainage, since the field can be left entirely dry. In cholecystitis, especially in the acute phase, it may be necessary to remove the gall bladder from the fundus toward the cystic duct. This method of cholecystectomy has been regarded as safer than other techniques because there is less chance of injuring the common bile duct but it renders hemostasis more difficult. The use of fibrin foam with thrombin, therefore, obviates the principal objection to this type of operation. During exposure and exploration of the common bile duct, there is occasionally troublesome bleeding from capillaries and small venous channels which is difficult to control with sutures and which prolongs the operation considerably. Such bleeding is easily and expeditiously stopped by the application of fibrin foam with thrombin.

Bleeding from the cut surface of the liver is so troublesome that many surgeons hesitate to remove even a small portion of the liver parenchyma; resection of larger areas are attended by serious hemorrhage. Experience has shown that biopsy of the liver is a simple procedure when the area of incision is packed with fibrin foam with thrombin. If necessary, hemostatic material may be held in place by a suture. Occasions demanding resection of large portions of the liver are exceptional. In a patient at the Peter Bent Brigham Hospital, fibrin foam with thrombin greatly facilitated an operation of this type.

CASE REPORT

A 45-year-old woman came to the hospital because of pain after meals, weakness, and tarry stools for months. A mass about 12 cm. in diameter was palpated in the left upper quadrant of the abdomen. Roentgenograms of the gastrointestinal tract showed a filling defect in the midportion of the stomach; the stools were positive for blood by the guaiac test. Abdominal exploration revealed a large gastric neoplasm which was attached to the left lobe of the liver. Since the lesion extended high in the stomach, the abdomen was closed and radical resection by a transthoracic approach was undertaken 3 weeks later, at which time subtotal gastrectomy and partial hepatectomy were carried out. A portion of the left lobe of the liver, measuring 9.5 by 7.4 by 4.8. cm. was removed after through-and-through catgut sutures had been placed and tied. The large vessels were clamped and ligated with figure-of-eight sutures. After this had been completed, the entire cut surface still bled freely from the small vessels. When this surface was covered with fibrin foam with thrombin, all bleeding was controlled. There was no evidence of hemorrhage from the cut surface of the liver during the postoperative course. The patient was last seen 14 months after operation; at that time, she was in good health and there was no evidence of recurrence. In retrospect, it would seem that silver clips would have been more satisfactory for the actively bleeding arteries than figure-of-eight sutures.

Oozing surfaces are occasionally encountered in biopsy or resection of large tumors in various sites; control of these may be time consuming or dif-

ficult to accomplish at all. Ten reports dealing with the use of fibrin foam with thrombin in these locations have made it clear that the material is very effective under such circumstances. During radical resection of two mixed tumors of the parotid gland, fibrin foam with thrombin was found helpful in securing hemostasis. The material is particularly valuable in dealing with these tumors because of the importance of saving all branches of the facial nerve. Since there is often bleeding in the region of this structure, it may be injured in the application of instruments to maintain hemostasis and much time is consumed because of the caution necessary in the placing of each hemostat and suture. The bleeding can be safely and quickly brought under control with fibrin foam with thrombin. There are also two reports of hemorrhage after the removal of portions of rapidly growing retroperitoneal tumors for microscopic study; in both instances the use of fibrin foam with thrombin produced satisfactory hemostasis after sutures had proved inadequate for the purpose. In three instances, the removal of large pelvic tumors left areas of peritoneum on the pelvic wall or on the bowel surface where oozing was difficult to control. Thin sheets of fibrin foam with thrombin stopped the bleeding promptly in each patient. The other three reports on the use of fibrin foam with thrombin in dealing with tumors are concerned with its use in resections of carcinomas of the head of the pancreas. The proximity of many important structures in this region makes the use of sutures difficult and hazardous. Control of capillary bleeding is more effective and less dangerous when fibrin foam with thrombin is used than when sutures are employed. Actively bleeding arteries must be ligated, as well as the larger veins.

Three additional reports of the use of fibrin foam with thrombin in biopsy of the pancreatic parenchyma indicate that the procedure is greatly simplified when this material is employed for hemostasis.

Biopsy of the spleen is attended by so much bleeding that it is seldom attempted when sutures are depended upon for control of bleeding. This may be carried out readily when fibrin foam with thrombin is used for hemostasis, as illustrated in the following report from the Peter Bent Brigham Hospital.

CASE REPORT

A 58-year-old woman entered the hospital because of intermittent fever, weight loss, malaise, and enlargement of the abdomen. On physical examination, the patient was found to have a greatly enlarged spleen. Biopsy of an enlarged cervical lymph node showed the presence of tuberculosis. A diagnosis of primary splenic tuberculosis was entertained and biopsy of the spleen was performed under local anesthesia. At operation, the spleen was found to be smooth, glistening, and bluish red in color. It was soft but tense; no tubercles were seen or palpated. Tissue was removed from the spleen for histologic study by making an elliptical incision 1.5 cm. in length and 1 cm. in depth. The splenic tissue was very friable and the site of the biopsy bled profusely. Fibrin foam with thrombin was packed into the incision and excess fluid removed with suction through a gauze sponge. All bleeding ceased within one minute. The material removed for histologic study showed no evidence of tuberculosis. There was no evidence of postoperative bleeding. The patient gradually became weaker and died four weeks after operation. At autopsy the scar of the incision in the spleen was well healed and very small. On histologic examination there was only a small amount of fibrin foam remaining and tissue reaction was minimal. The patient proved to have an unclassified disease of the hematopoetic system.

Fibrin foam with thrombin has been used to reduce the blood loss from oozing in the course of certain gynecologic operations, especially colporrhaphy and hysterectomy. The material was found effective in obtaining prompt hemostasis but the technique of application now used could probably be improved for use in these locations. Fibrin foam with thrombin may occasionally be use-

ful in the control of bleeding along the ureters and in a few other sites where the application of hemostats holds special dangers. However, it would seem that most of the bleeding in these operations can be controlled by sutures and by meticulous surgical technique, without the use of fibrin foam with thrombin. Among the instances in which fibrin foam with thrombin was used in gynecologic surgery, the following one from the Parkway Hospital, Brookline, is of particular interest.

CASE REPORT

A 48-year-old woman was admitted to the hospital for a vaginal plastic procedure. On the day before operation, she was given 200 mg. of dicumarol, as a prophylactic against venous thrombosis and embolism. The vaginal repair was carried out successfully. On the fourth postoperative day, 0.8 c.c. of furmethide was given in order to help empty the bladder. Since the prothrombin time, by Quick's method, was 40 seconds (control, 21 seconds) the patient also received 200 mg. of dicumarol. There was an unusually severe reaction with defecation, sweating, and faintness; a diffuse skin rash developed. On the eighth postoperative day, bright vaginal staining was noted; the prothrombin time was 238 seconds (control, 38 seconds). Examination showed oozing along the suture line in the anterior vaginal wall. Fibrin foam with thrombin was applied with immediate hemostasis; 64 mg. of vitamin K were also given intravenously. Eight hours later, the bleeding recurred, and the vagina was packed with gauze. On the following day, the incision was resutured because of continued bleeding. At this time, the prothrombin time was 180 seconds (control, 25 seconds); 64 mg. of vitamin K were again administered. The next day, an attempt was made to control the bleeding by instilling a solution of thrombin in the vagina, which resulted in temporary cessation of the oozing. This procedure was repeated later the same day and was followed by immediate hemostasis lasting 16 hours. The following day the prothrombin time was 115 seconds (control, 29 seconds). With the recurrence of vaginal bleeding another instillation of thrombin solution was given; this produced permanent hemostasis. The prolongation of the prothrombin time was out of proportion to the amount of dicumarol administered. While the hemostatic action was at first temporary, it finally controlled the hemorrhage and made transfusions unnecessary.

The course of events shows that local hemostasis can be secured by the application of human thrombin in a patient with elevated prothrombin time. It also illustrates the fact that thrombin is the active hemostatic agent while fibrin foam is a matrix to hold it. When very large amounts of thrombin are required and the absorption of the material holding the thrombin unimportant, thrombin-soaked gauze may be preferable to fibrin foam with thrombin.

Considerable use of fibrin foam with thrombin has been made in genitourinary surgery. In enucleation of the prostate by the suprapubic transvesical route, the control of hemorrhage from the prostate bed has been a difficult and important problem. If it is possible to control the bleeding completely at the time of operation, there would be no need for hemostatic bags and similar appliances. The convalescence would therefore be shorter and complications less likely. A hemostatic material for use in this location either should be soluble in urine or should disintegrate so that no fragments would remain to serve as a nidus for the formation of calculi. The substance should also adhere to the wall of the prostatic bed after application.

Observations on the use of fibrin foam with thrombin in prostatectomy have been carried out at the Peter Bent Brigham Hospital. The studies indicate that fibrin foam with thrombin is satisfactory under these conditions and that it may be further improved by variations in methods of its preparation. A detailed report is being prepared by Dr. W. C. Quinby. The use of fibrin foam with thrombin as a hemostatic agent in prostatectomy is illustrated by the following case report.

CASE REPORT

A 58-year-old man came to the hospital because of urination every half hour to hour, nocturia three times each night, dysuria, decreased caliber of the urinary stream, and inability to empty the bladder completely. These difficulties had been present for more than one year. On examination, both lateral lobes of the prostate were found enlarged and there was a large intravesical median lobe. The prostatic urethra measured 5 cm. in length. There were 100 c.c. of residual urine, which was free from infection. Under spinal anesthesia, suprapubic prostatectomy was carried out without preliminary drainage of the bladder. The prostate was easily enucleated; the bleeding was controlled by placing small strips of fibrin foam with thrombin along the prostatic urethra. Hemostasis was very satisfactory. The bladder was then closed around a suprapubic catheter and the abdominal wound reunited. No hemostatic bag was used. On the first postoperative day, the urine from the catheter was almost free of blood. The catheter was removed on the third day following operation; the patient immediately voided a normal stream of urine. Sutures were removed from the abdominal wound on the eighth postoperative day. When the patient was discharged on the twelfth day, the wound was well healed and the urinary stream entirely normal.

Rather frequently, in thoracic surgery, oozing surfaces are encountered, the bleeding from which is difficult to control by conventional techniques. One instance is in dealing with extensive adhesions between the visceral and parietal pleurae. As the lung is dissected free from the chest wall, troublesome oozing results. When packing is used to secure a dry field, the operation is considerably prolonged. These areas of bleeding were easily and quickly controlled when they were covered with thin sheets of fibrin foam with thrombin. The use of this hemostatic agent shortened the operation and resulted in a dry field at the time of closure.

One of the most important uses of fibrin foam with thrombin in thoracic surgery is for the control of capillary and venous bleeding in operations for removal of mediastinal tumors. It is sometimes hazardous to use sutures in the mediastinum because of the proximity of important anatomic structures. Such bleeding is readily controlled by means of fibrin foam with thrombin. More important is the use of this hemostatic agent in the beds of the mediastinal tumors. Here venous and capillary bleeding may create a serious situation analogous to the problems confronting the neurosurgeon in dealing with the beds of intracranial tumors. Fibrin foam with thrombin not only controls the bleeding quickly and completely but also at times permits the removal of large tumors in toto which could not otherwise be attacked successfully. This is illustrated by the following case report.

CASE REPORT

A 28-year-old man had a routine roentgenogram of the chest in the course of a general physical examination. There were no symptoms of any kind. The roentgenogram showed a large mass in the chest attached to the posterior mediastinum. Exploration was carried out. On separating the pleura a tumor, measuring approximately 17 cm. long and 12 cm. wide, was exposed. The ovoid tumor filled most of the posterior portion of the right thorax and extended from the hilus to the chest wall. It was attached to the surrounding tissues all along its surface. The size of the neoplasm made exposure difficult. Resection, however, was decided upon and carried out as carefully as possible, the entire tumor being removed in so far as could be determined macroscopically. The bed of the tumor was a mass of bleeding venous sinusoids. Attempts were made to control the bleeding by pressure and saline-soaked sponges. Only partial and temporary hemostasis was accomplished, for the bleeding recurred when the sponges were removed. This procedure occupied one hour. The blood pressure began to fall in spite of transfusions. Fibrin foam with thrombin was then placed over the entire bleeding surface, three bottles being used. Hemostasis was prompt and complete. The pleura was closed over the fibrin foam. The patient died on the day after operation. At autopsy there was no significant hemorrhage. Histologic study showed that the tumor was a rapidly growing fibrosarcoma.

In orthopedic and traumatic surgery, there are a few special situations in which it is important to have an absolutely dry field at the completion of the operation. A thin sheet of fibrin foam with thrombin readily controls the bleeding from the bone in amputations, with the result that no hematomas form in the wounds and the stumps are in excellent condition. When skin grafts are required in amputations, especially in revising amputation stumps, fibrin foam with thrombin controls the bleeding from the bone and soft tissues, leaving an absolutely dry field. For the same reason, this hemostatic agent has proved of value in arthroplasties. As in other types of surgery, fibrin foam with thrombin should be regarded as a supplement to conventional methods of hemostasis, and not as one to supplant meticulous care with tissues.

Persistent bleeding from injuries or operations in patients with hemophilia has long been a troublesome problem to surgeons. A large variety of local hemostatic agents have been used with little or no success and transfusions have been necessary for the most trifling wounds. While experience with fibrin foam with thrombin as a local hemostatic agent in hemophilia has thus far been limited to six instances, its value has been so clearly demonstrated in each that it seems to be the agent of choice in dealing with these lesions. In three patients, persistent bleeding from chronic ulcers of the leg was completely and permanently controlled by a single application of fibrin foam with thrombin. In another patient with hemophilia, this material stopped the bleeding from a laceration of the tongue, a large clamp being used to hold it in place. There were two instances in which lacerations of the extremities had bled persistently for more than 72 hours in spite of transfusions. In both patients, the application of fibrin foam with thrombin produced permanent hemostasis within a few minutes. Fibrin foam with thrombin has also been shown to control bleeding after extraction of teeth in patients with hemophilia. This experience as well as other studies on the use of fibrin foam with thrombin in dental surgery will be reported by Dr. P. K. Losch. It should be pointed out that hemostasis by fibrin foam with thrombin in patients with hemophilia is purely local and does not in any way affect the abnormality of the blood primarily at fault.

The present package in which fibrin foam with thrombin is now supplied for clinical use contains three bottles. One contains pieces of fibrin foam; the second, thrombin in the dry state; the third, physiologic saline solution. At the time of operation, about 10 c.c. of the saline solution are withdrawn by syringe and placed in the bottle of thrombin. The thrombin dissolves rapidly. The thrombin solution and the rest of the saline solution are mixed in a sterile basin on the operating table. Pieces of dry fibrin foam are cut to the size and shape required. They are then placed in the thrombin solution which quickly permeates the fibrin foam because of the porosity of the material. Saturation of the fibrin foam is rapid, being complete in less than two minutes. The permeation of the material is accompanied by a moderate amount of shrinkage, for which allowance must be made in cutting the fibrin foam. The fibrin foam is left in the thrombin solution ready for application as required in the course of the operation. Should more fibrin foam be required than was anticipated, an additional supply could be prepared within three minutes. It is important that the saline solution used to dissolve the thrombin be at room temperature or below and that it be kept away from heated radiators because the thrombic activity is rapidly destroyed at higher than room temperatures. The thrombin solution should be freshly prepared each day.

The techniques used in applying fibrin foam with thrombin to a bleeding surface must necessarily vary with the location on which it is used. In some

places it is desirable to employ thin sheets to cover a wide surface with a minimal amount of the material, while in tumor beds and other oozing cavities it may be advantageous to use much larger pieces. In general, the thrombin-soaked portions of fibrin foam are pressed into place on the bleeding surfaces by means of gentle pressure through cotton or gauze. The excess fluid is removed by suction. The cotton or gauze is then lifted away from the underlying fibrin foam which must be left in place since the clot which is formed is partially within the substance of the fibrin foam. The fibrin foam can be moulded to the shape of the tissue surface and will retain the configuration in which it has been pressed. Bleeding will recur if the fibrin foam is removed. However, if large masses of fibrin foam are used to fill a cavity, such as a tumor bed, it is possible to cut away the central portion without disturbing the freshly formed clot since this lies largely at the region of contact between the fibrin foam and the tissue. The reason for removing the central portion of large masses of fibrin foam is that it favors the rapid disappearance of the material. The final tissue reaction to a very large mass of fibrin foam is so slight as to be inconsequential clinically. It is clear, however, that the rate of disappearance of the material is more or less proportional to the volume left in place. Small fragments will disappear in 7 to 10 days, while it may take 4 to 6 weeks for larger masses to be completely absorbed.

Since fibrin foam with thrombin is a relatively new hemostatic agent it is apparent that its usefulness may often be increased by modifications of the technique herein presented which has been developed largely for the use of the material in neurosurgery. It is possible to prepare in the chemical laboratory a variety of fibrin foams differing in texture, porosity, and persistence time in the tissues. It may well be that in certain locations some of these may eventually prove more useful than the form now supplied.

The wide variety of operations in which fibrin foam with thrombin has been used indicates the general usefulness of the material. A contraindication to the use of this material is in the nose and throat of unconscious patients, or of those with diminished or absent gag reflex. The inhalation of bits of fibrin foam, especially when coated with bacteria containing mucus, would be likely to carry infection to the bronchi and pulmonary tissues.

SUMMARY

Experimental studies have shown that fibrin foam with thrombin is an effective absorbable hemostatic agent in the liver, peritoneal cavity, abdominal wall, kidney, and lung. In each of these locations the absorption of the material is accompanied by only slight tissue reaction.

Clinical appraisal of fibrin foam with thrombin as an absorbable hemostatic agent in general surgery has been carried out in 240 patients. It has proved effective in controlling oozing surfaces and venous bleeding under a wide variety of circumstances, including wounds in patients with hemophilia.

The use of fibrin foam with thrombin should not replace the careful control of bleeding by means of meticulous dissection and adequate placing of sutures. It should be reserved for those particular situations in which an absorbable hemostatic agent is desirable to prevent the injuring of vital anatomic structures or to control oozing which is not easily stopped by conventional methods, as in the beds of tumors and the cut surface of parenchymatous organs.

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THE OCCURRENCE OF BACILLUS HISTOLYTICUS IN ACCIDENTAL WOUNDS WITHOUT RECOGNIZED SPECIFIC INFECTION

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THE title of this paper was suggested by the observations of MacLennan,[1] that in addition to one fatal case of a war wound in the Middle East in which *Clostridium histolyticum* was found as the sole infecting agent, it also "occurred along with other pathogenic clostridia in nine cases of gas gangrene, all of which were fatal."

This contrasts sharply with our own recent experience in the study of civilian wounds[2, 3] in which we found *Bacillus histolyticus* in 18 cases out of approximately 2,500 wounds. Only 1 of these 18 cases (Case 1) resulted in death, which was attributed at the time not to *B. histolyticus* but to *Bacillus perfringens*. I have been privileged to see only one of these cases clinically but with the aid of my assistants have rechecked all of the cultures of this organism submitted either for identification or confirmation. Permission to present these brief abstracts of the case histories has been granted by the surgeons in charge.

Work done under a contract recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Columbia University.

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COMPOUND FRACTURES

B. histolyticus was recovered in 7 cases of compound fractures.

CASE 1.—J. D. S. (L.G.), a private in the Air Corps, received a compound fracture of the ankle in an automobile accident. He was admitted to the hospital five hours afterward. The wound was badly contused and filled with cinders from the roadside.

The wound was completely débrided. It was treated locally with sulfanilamide and x-ray, and an undesignated amount of gas gangrene antitoxin was administered. But in spite of all treatment the emphysema extended up the fascial planes and it became necessary about three hours after the development of the infection to amputate the leg. The patient died about four days after admission.

Autopsy showed extensive edema of the lungs suggesting hemorrhagic bronchopneumonia.

Smears of the débrided tissues showed streptococci, staphylococci, and gram-positive rods, some with terminal or subterminal spores. Mixed anaerobic cultures in milk gave a stormy fermentation. A transfer of this culture sent to me yielded *Micrococcus epidermidis, Bacillus sporogenes,* and *B. histolyticus.* The latter was fully virulent for guinea pigs, producing the characteristic myolysis on intramuscular injection and the peculiar lytic destruction of the skin so characteristic of this species on subcutaneous inoculation. *B. perfringens* was not recovered, but Kuhns* stated that *Clostridium welchii* was present in a blood culture taken at the time of amputation. However, both aerobic and anaerobic cultures taken from the lungs at autopsy were negative but the "findings in the blood vessels, heart and liver were compatible with *Cl. welchii* infection."

CASE 2.—W. B. (M.G.), a white man 48 years old, had a partial avulsion of the right index finger with compound fractures of the second and third phalanges. He was admitted to the hospital within one hour and treatment was started about two and three-fourths hours after the injury. The wound was apparently only slightly contaminated but particles of glass were present. The finger was amputated and sulfadiazine was administered locally, intravenously, and orally. Tetanus antitoxin was also administered. The wound was dressed on the seventh and eleventh days. A mild infection appeared but its character was not determined. Recovery was otherwise uneventful and complete on the eighteenth day.

The débrided tissues yielded a hemolytic streptococcus, Group A, a nonhemolytic streptococcus, *Micrococcus aureus, micrococcus albus, micrococcus tetragenus, Sarcina lutea,* "hay bacillus," *Bacillus pasteurianus,* and *B. histolyticus,* the latter fully virulent.

CASE 3.—D. J. (C.H.), a Negro man 70 years old, suffered a compound fracture of the tibia and fibula and lacerations of the forehead in a street accident. He was treated within one hour. Contamination was regarded as slight. He was given 3,000 units of tetanus antitoxin and 3,000 units of *B. perfringens* antitoxin. The wound on the finger was completely débrided, dusted with sulfanilamide and sulfadiazine, and the bony parts were fixed by plates, screws, and plaster. Sulfadiazine was also given orally and intravenously, a total of 47 Gm. in nine days. The wound on the head was also dusted with sulfadiazine and sutured. The scalp wound healed without complications but the leg became infected and developed a persistent osteomyelitis. There was no union after twenty-three days.

Cultures from the débrided tissues yielded many species of bacteria, among which were identified a nonhemolytic streptococcus, Group D, *Micrococcus varians, M. epidermidis, Flavobacterium sp. ?, Bacillus bifermentans,* and *B. histolyticus,* apparently nonpathogenic upon subcutaneous inoculation of a guinea pig.

Unfortunately, through some oversight, no cultures were made after the initial operation.

CASE 4.—A. C. (C.H.), a white man 39 years old, suffered a compound fracture of the lateral malleolus and a slight diastasis of the tibia and fibula. The wound was cleansed, débrided, sprinkled with sulfanilamide, and left open. Sulfadiazine was administered orally at once and occasionally during the following eight days, a total of 51 Gm.

There was no evidence of infection on the twelfth day and although healing was still incomplete the patient deserted and did not return. The débrided tissues yielded a nonhemolytic streptococcus, Group D, *M. epidermidis, Micrococcus aurantiacus, Bacterium aerogenes, Bacillus tertius,* and *B. histolyticus,* fully virulent. On the tenth day a culture showed a nonhemolytic streptococcus, *M. aureus* and a "hay bacillus."

*The data in this case were supplied by Capt. D. M. Kuhns, formerly Chief of the Laboratory Service, Medical Corps, Letterman General Hospital, San Francisco, Calif.

CASE 5.—M. B. (M.G.), a white man 26 years old, suffered a compound fracture of the right radius and ulna, a compound fracture of the lower part of the right leg, and a laceration of the forehead in a railroad yard. He was hospitalized within one hour in fair condition but with impending shock. Operation was started during the next hour. The wounds were contaminated by cinders. It was considered necessary to amputate both the arm and the leg above the sites of fracture. The stumps were dusted with sulfanilamide and closed, the arm without tension, the leg with tension. The laceration on the forehead was also débrided and completely closed. Sulfadiazine was administered systemically, a total of 47 Gm. in thirteen days.

The débrided tissues showed several species of bacteria among which were identified *Bacterium coli, Bacterium proteus, Bacillus tetani,* and *B. histolyticus,* the two latter fully virulent. The wounds in the head and arm healed in twenty-four days without any clinical evidence of infection except a slight serous discharge in the arm.

On the twelfth day there was still some purulent exudate in the leg and *M. aureus, M. albus, Bact. coli,* and *Bact. proteus* were found in a culture taken on that day, but on the twenty-fourth day all clinical signs of infection had disappeared. However, the patient remained in the hospital for a total of sixty-five days, when he was discharged using an artificial leg.

CASE 6.—W. J. W. (C.H.), a Negro man 66 years old, suffered a compound comminuted fracture of the left tibia and fibula on a country road. He was brought into the hospital after six hours. He was given 3,500 units of tetanus antitoxin and 4,000 units of *B. perfringens* antitoxin. The wounds were débrided and the fractures were reduced and fixed with Steinmann pins and a plaster cast. Sulfanilamide was used locally and sulfadiazine systemically, a total of 93 Gm. in seventy-five days of hospitalization. This patient had a spiked fever curve with temperatures between 101 and 102° F. but the dressing was not changed until the twenty-fifth day, at which time it was decided to amputate the limb. The record is incomplete from there on; the case was cited as an unsuccessful demonstration of the Trueta-Orr technique.

Cultures from the débrided tissues showed hemolytic streptococci, *Streptococcus fecalis,* Group D, *Micrococcus candidus,* an unidentified "hay bacillus," *B. tertius, B. sporogenes,* and *B. histolyticus,* the latter fully virulent. A culture on the twenty-fifth day showed *M. aurantiacus, Bact. coli, Str. fecalis, B. sporogenes, Bacillus nonfermentans,* and *B. histolyticus.*

CASE 7.—L. P. (C.H.), a Negro woman 79 years old, had a grossly contaminated compound fracture of the radius and ulna with severe stripping of the periosteum, caused by falling in a field. She was treated in the hospital within one hour, all devitalized tissue and dirt being débrided and the fracture reduced. The wound was dusted with sulfathiazole and left open, fixed under plaster. Tetanus antitoxin, 3,000 units, and *B. perfringens* antitoxin, 4,000 units, were administered. There was no evidence of infection. Recovery was uneventful. The patient was released on the twenty-fifth day.

Cultures of the débrided tissue yielded *B. histolyticus* (fully virulent), *B. bifermentans,* nonhemolytic streptococci, and *B. proteus.* No subsequent cultures were made.

SUMMARY OF COMPOUND FRACTURES

Inspection of Cases 1 to 7 shows that only Case 1 resulted fatally and in that instance death was attributed primarily to *B. perfringens,* as *B. histolyticus* was not suspected until I demonstrated it in a mixed culture. All of the other patients survived, 2 without infection, 1 with a trivial infection, and 3 with serious infections. But with one exception *B. histolyticus* appeared only in the cultures made from the débrided tissues and there was no evidence of lesions which could be attributed to this species. Yet all but one of these cultures of *B. histolyticus* were fully virulent, producing typical lesions in guinea pigs, and all were associated with other aerobic and anaerobic species of bacteria. In one instance, *B. histolyticus* persisted until the twenty-fifth day, at which time the leg had to be amputated.

MacLennan[1] observed 1 case in which *B. histolyticus* was apparently the sole infecting organism. "The terminal picture was in every way similar to that produced in the thigh of a guinea pig experimentally, that is a rapid and extreme digestion and liquefaction of all the related soft tissues." Nothing of

the sort was apparently seen in Case 1 but we note that in 5 of MacLennan's cases of mixed infection where the appearance of the infected muscles was recorded, they were invariably described as being very dark in color—"dark red," "purple," or "black" and "of a very soft consistency" but, "digestion of tissues was apparently not observed."

LACERATIONS

There were 5 cases of lacerations from which *B. histolyticus* was recovered.

CASE 8.—A. E. (C. H.), a white man 21 years old, received a stab wound in the chest, penetrating the thoracic cavity. He came under treatment during the fourth hour after the injury. There was no evidence of gross contamination. He was given 3,000 units of tetanus antitoxin and 4,000 units of *B. perfringens* antitoxin. The wound was treated with sulfanilamide and sulfadiazine, and a total of 28 Gm. of sulfadiazine was given systemically during a week's stay in the hospital. Healing occurred without complications.

A culture made on admission yielded a nonhemolytic streptococcus, Group D, *M. albus*, *M. epidermidis*, an unidentified "hay bacillus," *B. tertius*, and *B. histolyticus*, apparently nonpathogenic on both subcutaneous and intramuscular injection of guinea pigs.

CASE 9.—W. G. (C. H.), a male Negro, 18 years old, received multiple stab wounds of the chest and abdomen, one penetrating the peritoneal cavity and the stomach. He came under treatment during the second hour after the injury. He was given 3,000 units of tetanus antitoxin and 4,000 units of *B. perfringens* antitoxin. A laparotomy was performed to repair the wound in the stomach and all incisions and wounds were completely closed without tension. Sulfanilamide was used locally and sulfadiazine systemically, a total of 53 Gm. in fifteen days.

On the fifth day the major stab wound was obviously infected and on the sixth day a kernel of corn (!) was extruded from it, showing that the débridement had been incomplete. From that time on healing was uneventful.

A culture from the débrided tissue showed a nonhemolytic streptococcus, Group D, *M. albus*, *M. epidermidis*, *M. candidus*, an unidentified "hay bacillus," and *B. histolyticus*, which failed twice to produce the characteristic lesions on subcutaneous inoculation into guinea pigs.

A culture taken on the fifth day showed *M. aureus*, *M. albus*, *Bact. aerogenes*, *Corynebacterium sp.* (?), and a nonhemolytic streptococcus.

A culture taken on the twelfth day showed *M. aureus*, *B. aerogenes*, and others not identified. If *B. histolyticus* was present in either of these later cultures it was not isolated.

CASE 10.—E. O'B. (M.G.), a white man 23 years old, received a severe laceration and avulsion of his left forearm in a warehouse accident, which exposed a strip of muscles about 8 cm. long. He was brought to the hospital within one hour. Treatment was started about three and one-half hours after the injury and consisted in the administration of 10,000 units of *B. perfringens* antitoxin and 10,000 units of *Bacillus septicus* antitoxin. No sulfonamide drugs were used. The area was grafted at once with split-thickness grafts taken from the thigh and sutured into place. Most of these grafts took satisfactorily, but certain areas which continued to granulate were treated with wet dressings. Complete healing occurred in about two and one-half months.

The débrided tissue yielded a nonhemolytic streptococcus, Group D, *M. aureus*, an unidentified "hay bacillus," *B. bifermentans*, and *B. histolyticus*, which was fully virulent. Unfortunately, no further cultures were made.

CASE 11.—L. M. (C.H.), a Negro man 37 years old, received multiple stab wounds of the arm and chest in a street fight. He was treated within the first hour. The flexor tendon was severed and the radial artery was injured. Tetanus antitoxin, 3,000 units, were administered. He also received 500 c.c. whole blood. The flexor tendon and the radial artery were repaired and all wounds were closed without tension. No drugs were used locally but infection developed and sulfadiazine was given systemically from the ninth to the sixteenth day, a total of 25 Gm. The wounds were healed, however, in about twenty-two days.

A culture made from the arm at operation yielded *Streptococcus ignavus* (?), *M. epidermidis, M. candidus,* "hay bacillus," and *B. histolyticus which* was apparently only slightly pathogenic, producing moderate edema on subcutaneous injection of a guinea pig.

Cultures made from débrided tissue from the wounds in the chest yielded *B. bifermentans B. sporogenes, Bact. aerogenes,* a micro-aerophilic alpha-hemolytic streptococcus, *M. candidus,* and *B. histolyticus* (fully virulent).

A culture taken from the arm on the ninth day showed *M. aureus,* a hemolytic streptococcus, *Bact. aerogenes, C. sp.* (?). One taken from the arm on the fifteenth day showed *M. aureus, M. aurantiacus, Bacillus cloacae, Bact. aerogenes, C. sp.* (?), *B. sporogenes,* a nonhemolytic streptococcus, and *B. bifermentans.* If *B. histolyticus* was present on the ninth and fifteenth day it was not recognized or isolated.

CASE 12.—S. C. (A.C.H.), a white woman, 63 years old, received a laceration of the lower part of the right leg and a fracture of the fibula in an automobile accident. She was treated during the first hour. The wound was grossly contaminated with dirt and clothing. It was débrided and left open. Sulfanilamide was used locally and sulfadiazine by mouth, 30 Gm. during a period of ten days. Healing was complete in six weeks without infection.

Cultures from the débrided tissues showed, among others not identified, a nonhemolytic streptococcus, *M. epidermidis,* a "hay bacillus," *Bact. aerogenes, Bacterium alkaligenes, B. perfringens, Bacillus putrificus, B. bifermentans, Bacillus cochlearius* (?), and *B. histolyticus* (fully virulent). No other cultures were made.

SUMMARY OF LACERATIONS

None of these cases ended fatally. Two wounds healed without infection, one healed after a minor infection, while two healed after serious infection. *B. histolyticus* was demonstrated only in the débrided tissues from these cases and there was never any clinical indication of its presence after the initial operations.

Three of these cultures were fully virulent; two were apparently nonvirulent.

GUNSHOT WOUNDS

There were three gunshot wounds.

CASE 13.—E. S. (D.G.H.), a white male, 18 years old, was accidentally shot by a hunting companion with a shotgun, in the sacrum, posterior pelvis, and gluteal regions. He was brought immediately to another hospital, where the wound was débrided but not completely, as subsequent x-rays showed that some of the shot had apparently entered the posterior pelvis. I was present and took some debris from the wound, including pieces of clothing and gun wads from all of which cultures were made.

The principal wound, about 7 inches long, running transversely across the sacrum, was closed with silk sutures, a Penrose drain protruding from each end of the wound. Prophylactic doses of gas gangrene antitoxin and tetanus antitoxin were administered but the amounts given are not available.

On the third day the patient was transferred to the Denver General Hospital. Aside from occasional pain in the region of the wound there were no complaints on the part of the patient. His general condition was good. There was no evidence of injury to the spinal cord, no loss of sensation, and all reflexes were satisfactory. X-rays showed "numerous metallic foreign bodies throughout both the gluteal regions with the largest concentration reaching into the sacrum."

The drain was removed on the ninth day after the wound was received. Recovery was uneventful. Smears from the débrided tissues showed numerous pus cells and a few clumps of gram-positive cocci. The cultures yielded "hay bacillus," *Streptococcus anginosus, Bacillus sphenoides, Bacillus subterminalis,* and *B. histolyticus,* the latter fully virulent.

CASE 14.—G. P. (C.H.), a white man 26 years old, was shot in the forearm, in the thigh, and in the head with a pistol. He was brought in for treatment within one hour. The skull was fractured but not penetrated by the bullet. He was given 500 c.c. of whole blood and the wounds were cleansed, débrided, and closed without tension. Sulfanilamide was used locally and sulfadiazine systemically, 37 Gm. in a period of eleven days.

There was no infection and healing was complete in ten days.

Cultures from the débrided tissue yielded a hemolytic streptococcus, a nonhemolytic streptococcus, Group D, *M. candidus, M. aurantiacus, M. epidermidis, Sarcina sp.* (?), *B. tertius,* and *B. histolyticus.* The latter was only moderately virulent for a guinea pig inoculated subcutaneously, producing edema and hematoma, but no break in the skin.

CASE 15.—K. B. (C.H.), a Negro man 31 years old, received multiple wounds from a pistol in the abdomen and chest during a fight in the street. Treatment was begun within one hour. The pleural cavities were not penetrated but the peritoneal cavity was, with damage to the mesentery. The mesentery and peritoneum were repaired and the wounds were closed without tension. Whole blood, 250 c.c., were transfused. No antitoxin was given but sulfadiazine was administered systemically, 70 Gm. in ninteen days.

About the twentieth day an abscess developed at the point of exit of the bullet in the lumbar region. This was deeply incised and drained on the twenty-sixth day, after which complete healing occurred, the patient being discharged on the forty-fifth day.

A culture from the débrided tissues showed *M. albus, M. varians, M. epidermidis, B. tertius,* and *B. histolyticus.* A culture taken from the abscess on the twentieth day yielded *M. aureus,* a nonhemolytic streptococcus, and *B. histolyticus.* One taken on the twenty-fifth day yielded *M. aureus,* a nonhemolytic streptococcus, *B. coli,* and *B. histolyticus.* The thirty-seventh day showed the same species plus an unidentified species of Corynebacterum. *B. histolyticus was still present.* Of the four cultures of *B. histolyticus* recovered, we had an opportunity to recheck only the first, that is, the one from the débrided tissues, which was fully virulent.

SUMMARY OF GUNSHOT WOUNDS

All of these patients recovered, 2 without infection, 1 after the development of a deep abscess. In 2 of these cases *B. histolyticus* was recovered only from the débrided tissues; in Case 15 it was recovered not only from the débrided tissues but also from cultures taken on the twenty-fifth and thirty-seventh days.

Two of these cultures of *B. histolyticus* were fully virulent, one was only moderately so.

BURNS

B. histolyticus was found in two cases of burns.

CASE 16.—A. S. (C.H.), a white man, 52 years old, received first, second, and third degree burns on the chest, neck, back, and shoulders in an explosion of kerosene. About 25 per cent of the surface of the body was burned but less than 5 per cent was regarded as third degree.

This patient was not received in the hospital until after two or three days had elapsed. At that time there was evidence of gross contamination with ants and maggots crawling over the burned area.

These were thoroughly cleansed and covered with pressure dressings soaked in merthiolate. Saline solution tub baths were given at frequent intervals. Medication included 1,700 c.c. of plasma, 500 c.c. of blood, and 25 Gm. of sulfathiazole systemically in ten days. The patient was discharged in sixty-five days but the time of complete healing was not recorded.

Cultures from the débrided tissues showed a hemolytic streptococcus, a nonhemolytic streptococcus, Group D, *M. epidermidis,* an unidentified gram-negative rod, *B. perfringens* and *B. histolyticus* (fully virulent).

A culture taken on the eleventh day showed a hemolytic streptococcus, *M. aureus, B. coli, Micrococcus luteus, M. aurantiacus, S. sp.* (?) and *C. sp.* (?). One taken on the twenty-sixth day showed a hemolytic streptococcus, *M. aureus,* and *M. epidermidis.*

CASE 17.—R. D. (C.H.), a white male, aged 4 years, was scalded by hot water on the chest and arms. He was brought in for treatment during the third hour after the injury, which was regarded as third degree but involving only 5 to 9 per cent of the surface area. He was given 1,500 units of tetanus antitoxin before admission and 3,000 units more afterward. He was treated with saline solution pressure dressings. No sulfonamides were used. Healing was uneventful and complete in thirteen days' time.

The débrided tissues showed *M. epidermidis, M. candidus,* an unidentified gram-negative rod, and *B. histolyticus* (moderately virulent).

SUMMARY ON BURNS

Both patients recovered, one without signs of infection, one after a severe infection. *B. histolyticus* was recovered from the débrided tissues of both pa-

tients but was not recovered from subsequent cultures and there was never any clinical evidence of its presence. One of the cultures was fully virulent, one only moderately so.

These are believed to be the first cases of burns in which *B. histolyticus* has been isolated.

GENERAL DISCUSSION

The occurrence of *B. histolyticus* in accidental wounds, as presented here, is regarded simply as an expression of the widespread occurrence of this organism in nature. It should be distinctly understood that the débrided tissues were minutely studied in these cases as a means of determining the potential pathogenic agents; we do not advocate such cultures routinely since it is quite apparent that they have little or no relation to the subsequent development of infections if surgical treatment is instituted within a reasonable period of time.

Ever since the discovery of *B. histolyticus* as one of the pathogenic factors in gangrenous wounds by Weinberg and Sequin,[4] in 1916, and their demonstration of its remarkable and peculiar pathogenic properties in experimental animals, there has been much speculation and discussion as to its actual role in accidental infections. Weinberg and Sequin recovered it in 8 out of 30 gangrenous wounds before describing it; they recognized that these cases were exceptionally severe as 4 were fatal and the other 4 required amputations. They later[5] emphasized that the rapid liquefaction of tissues produced by the toxin of this organism was unusually favorable to the synergic growth of other anaerobic bacteria such as *B. perfringens* and *B. edematiens* (*Bacillus novyi*). Legros[6] was apparently the first to describe a human case in which the lesions were similar to those in animals; this was a mixed infection with cocci, *B. edematiens* and *B. sporogenes.*

Pure infections are indeed exceptional, as Combiesco[7] pointed out. Weinberg saw only one, which required immediate amputation, and I have seen no records of others prior to those of MacLennan.[1] It seems probable, therefore, that the characteristic lesions as seen in experimental animals and in a few rare accidental pure infections are masked and modified in the usual mixed infections in gaseous gangrene to such an extent that they can seldom be recognized. But there is no doubt, on the other hand, that a virulent *B. histolyticus* may play a profoundly important role when it occurs in a mixed infection.

B. histolyticus is a common organism in nature and has a widespread distribution. I recovered it from human feces in 1923[8] Although Kahn[9] failed to recover it in a large series of stool examinations, Torrey[10, 11] isolated it from the ileocecal region of two patients who had coleotomies, and Weinberg, Renard, and Davesne[12] found it in two gangrenous appendices. It probably occurs not uncommonly in the intestinal tracts of man and animals from which it readily finds its way into the soil.

Peterson and I[13] obtained it from arable soil in California, Chiari[14] from soil and tannery wastes in Germany. Whitehead and I[15] also obtained several strains from African poisoned arrows pasted with a mixture of poisonous plant juices in clay.

Although Weinberg and Sequin regarded *B. histolyticus* as an obligate anaerobe, I showed, in 1923,[16] that it was a facultative aerobe; I believe that it can be isolated more easily by aerobic than by anaerobic methods, but its colonies are minute and are likely to be overlooked in a mixed culture by all but the best trained and most meticulous bacteriologists. This accounts for the fact that it was not discovered until 1916 and that it is seldom reported even today. Thus,

in the present study of 2,493 contaminated civil wounds by 9 cooperating hospitals, only 3 submitted cultures containing *B. histolyticus*. It seems significant that of 15 cultures from these 3 hospitals in which we found *B. histolyticus*, 11 came from a single hospital, 7 of these being pure and already identified correctly, while 1 was pure but had not been identified; 2 were impure but were suspected to contain *B. histolyticus*, and 1 was pure but had been tentatively identified as an unknown species of "alkaligenes."

Another hospital submitted 3 cultures, 1 pure and identified, 1 impure with suspected *B. histolyticus*, and 1 pure but not identified. Still another hospital submitted a single culture, impure and unidentified.

SUMMARY

B. histolyticus was demonstrated in cultures taken from débrided tissues in 17 civil wounds. There were 7 compound fractures, 5 lacerations, 3 gunshot wounds, and 2 burns. These are believed to be the first records of *B. histolyticus* in connection with burns.

Only 1 case, that of a compound fracture, proved fatal. This was a typical case of gaseous gangrene caused by *B. perfringens* and other bacteria. The typical lesions produced by pure infections of *B. histolyticus* were probably masked and were not recognized.

All of the other patients recovered and the peculiar lesions of infection by *B. histolyticus* were not recognized in any case.

Persistence of *B. histolyticus* in an infected wound was noted in one case of compound fracture of the leg as late as the twenty-fifth day, when the leg had to be amputated. Persistence to the thirty-seventh day was observed also in a case of multiple pistol shot wounds.

The occurrence of *B. histolyticus* in wounds is regarded solely as an expression of its widespread occurrence in nature. If wounds are promptly and adequately débrided it rarely persists. If gaseous gangrene develops, the peculiar lesions produced by this organism in pure infections are likely to be masked and overlooked. It may persist in a mixed infection for twenty-five to thirty-seven days without giving any clinical indication of its presence.

The comparatively infrequent demonstration of this organism in accidental wounds probably gives an erroneous conception of the actual frequency of its occurrence owing to the fact that it is so easily overlooked in a bacteriologic examination of a mixed infection.

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THE OCCURRENCE AND POSSIBLE SIGNIFICANCE OF BACILLUS TETANI IN COMPOUND FRACTURES, LACERATIONS, GUNSHOT WOUNDS, AND BURNS

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THE writing of this paper was suggested by the fact that out of a total of 2,493 civil contaminated wounds studied under the Contaminated Wound Project, there were 11 in which *Bacillus tetani* was recovered from the débrided tissues. None of these patients developed tetanus while in the hospital and none is known to have done so since, although contact with some of the patients has been lost. These 11 cases were located in four hospitals, as follows:

Charity Hospital, New Orleans, La.	2 cases
Detroit Receiving Hospital, Detroit, Mich.	6 cases
Massachusetts General Hospital, Boston, Mass.	1 case
Cincinnati General Hospital, Cincinnati, Ohio	2 cases

One patient, treated in Charity Hospital for a burn, failed to yield *B. tetani* from the débrided tissue but after a transfer to another hospital on the thirty-second day was reported to have developed tetanus on the thirty-fifth day, from which he eventually recovered.

COMPOUND FRACTURES

There were 5 compound fractures, 1 of which was complicated by a gunshot wound.

CASE 1.—J. G. (C. G. H.), a Negro man 33 years old, July 19, 1942, received a compound fracture of the proximal phalanx of the left fifth finger and a pistol wound in the shoulder. He was admitted to the hospital within one hour, and operated upon during the third hour after the injury was received. He received a prophylactic dose of tetanus anti-

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toxin. A portion of the bone of the finger was removed and an aluminum splint was applied. Débridement of the gunshot wound was regarded as somewhat incomplete and unsatisfactory. Sulfanilamide was applied locally and 23 Gm. of sulfadiazine were given orally during a period of nine days. No serious infection occurred at this time.

The débrided tissues showed *Micrococcus aureus, Streptococcus viridans, Bacillus aerogenes, Bacillus perfringens,* and *B. tetani.*

This patient was seen last Aug. 17, 1942, at which time the wound was well healed superficially but there was still some local edema and induration and little function of the proximal interphalangeal joint. An attempt in August, 1944, to ascertain the subsequent history of this patient failed.

CASE 2.—M. B. (M. G. H.), a white man 20 years old, Sept. 13, 1942, suffered a compound fracture of the right radius and ulna, a compound fracture of the lower part of the right leg, and a laceration of the forehead in an accident in a railroad yard. He was hospitalized within one hour in fair condition but with impending shock. Operation was started during the next hour. The wounds were contaminated by cinders. It was considered necessary to amputate both the arm and leg above the sites of fracture. The stumps were dusted with sulfanilamide and closed, the arm without tension, the leg with tension. The laceration on the forehead was also débrided and completely closed. Sulfadiazine was administered systemically, a total of 47 Gm. in thirteen days.

The débrided tissues showed several species of bacteria, among which were identified *Bacterium coli, Bacterium proteus, B. tetani,* and *Bacillus histolyticus,* the two latter fully virulent.

The wounds in the head and arm healed in twenty-four days without any clinical evidence of infection except a slight serous discharge in the arm.

On the twelfth day there was still some purulent exudate in the leg and *M. aureus, Micrococcus albus, Bact. coli,* and *Bact. proteus* were found in a culture taken on that day but on the twenty-fourth day all clinical signs of infection had disappeared. However, the patient remained in the hospital for sixty-five days, when he was discharged using a wooden leg. Up to Sept. 12, 1944, he had not developed tetanus.

CASE 3.—E. C. (C. H.), a Negro man 24 years old, Jan. 8, 1943, was struck by an automobile and sustained a compound fracture of the left radius. He was admitted to the hospital within one hour and received 3,000 units of tetanus antitoxin and 4,000 units of *B. perfringens* antitoxin. The wound was débrided during the third hour; the fracture was reduced and the defect closed with cotton sutures without tension. The arm was fixed in plaster. No drug was used locally in the wound but 22 Gm. of sulfadiazine and sulfathiazole were administered orally during the first four days during which the patient's progress was uneventful, and after which he was transferred to another hospital where the fracture healed without infection. May 10, 1943, there was only a slight stiffness of the wrist joint. Sept. 5, 1944, he was reported as not having had tetanus.

Cultures made from the debrided tissues yielded *Micrococcus epidermidis, Bact. coli, Bacterium cloacae, Bacterium alkaligenes, Bacillus tertius,* and *B. tetani.*

CASE 4.—J. T. (D. R. H.), a Negro man 54 years old, Feb. 20, 1943, was struck by an automobile and sustained a compound fracture of the lower third of the tibia and fibula of the left leg in a city street. He was admitted to the hospital within one hour and given 1,500 units of tetanus anittoxin but the operation was deferred to the sixth hour owing to congestion in the operating rooms at the time.

The laceration was about three inches in length, through which approximately three inches of tibia protruded. The wound and exposed bone were very dirty. All of the lacerated muscles and exposed and contaminated tissues were completely débrided. The wound was irrigated briefly but thoroughly with physiologic saline solution from the depths outward; the fracture was reduced and the skin closed over it with silk sutures after which a plaster cast with three Steinmann pins was applied.

No drug was used locally but 37 Gm. of sulfadiazine were given during his thirty-two days in the hospital. When the cast was removed after seventy-five days the wound was found to be completely healed.

The débrided tissues yielded a nonhemolytic streptococcus, *M. epidermidis, Micrococcus tetragenus, B. perfringens,* an unidentified nonpathogenic bacillus, and *B. tetani.*

He was last seen about one year later and had not developed tetanus.

CASE 5.—G. Z. (C. H.), a white male, 10 years old, July 14, 1943, fell in a field and suffered a compound fracture of the radius and a simple fracture of ulna. Dirt was forced into the wound. He wrapped a rag around the wound and went home. An ambulance was called, at which time the fracture was reduced, the wound covered with sterile gauze, and an aluminum splint applied. He was given sulfanilamide locally and systemically but no antitoxin.

On the second day the wound became infected and he was brought to the hospital where evidence was found of incipient gaseous gangrene. The wound was then thoroughly débrided for the first time. The wound was packed with sulfanilamide, sulfadiazine, and methylene blue powdered together and he was also given 30,000 units of tetanus antitoxin, 60,000 units of *B. perfringens* antitoxin and 1,250 c.c. of whole blood. He also received 12 Gm. of sulfadiazine systemically. Response was slow but the wound was completely healed in about sixty days.

The débrided tissues yielded nonhemolytic streptococci, *B. perfringens, B. tertius, Bacillus bifermentans, Bacillus capitovalis,* a "hay bacillus," *B. coli,* and *B. tetani.* We rechecked three separate cultures of this strain of *B. tetani.* A culture taken on the third day showed hemolytic and nonhemolytic streptococci, *B. bifermentans, Bacillus sporogenes, B. tertius, Bact. coli, Bact. proteus,* and *Bact. cloacae. B. perfringens* and *B. tetani* were not recovered. A culture taken on the eleventh day showed hemolytic streptococci, *Bact. coli, B. aerogenes, B. bifermentans, B. sporogenes,* and *B. perfringens.* Again *B. tetani* was not recovered.

This patient was reported Sept. 5, 1944, as free from tetanus up to that date.

LACERATIONS

There were 5 lacerations.

CASE 6.—R. H. (D. R. H.), a negro woman, 25 years old, June 7, 1942, cut the back of her right wrist, severing the extensor tendons of the third, fourth, and fifth fingers and the extensor carpi ulnaris. She was admitted to the hospital during the first hour and received no antitoxin nor drugs. Under brachial block anesthesia, the area around the wound was washed with soapy water, completely débrided, and irrigated with 4 liters of sterile physiologic saline solution. The tendons were reunited with silk and catgut ligatures and the wound was closed under slight tension. The hand was dressed in extension using a plaster mold. Healing occurred in twelve days and function has been excellent.

The débrided cultures yielded *Micrococcus varians, Micrococcus candidus, M. epidermidis,* an unidentified species of Corynebacterium, *B. capitovalis,* and *B. tetani.* We rechecked two separate cultures of this strain of *B. tetani.*

She was last seen about one year later and had not developed tetanus.

CASE 7.—M. V. (C. G. H.), a Negro woman 26 years old, June 12, 1942, cut her right thumb with a piece of glass, resulting in a division of the extensor pollicus longus tendon. It was wrapped in a "clean" cloth as a first-aid dressing. She was admitted to the hospital during the third hour and operated upon during the sixth hour after the injury was received. A prophylactic dose of tetanus antitoxin was given. The laceration was débrided and the tendon repaired. The wound was dusted with sulfanilamide and closed with silk ligatures. She also received 16½ Gm. of sulfadiazine systemically during a period of seven days in which healing occurred without evidence of infection.

The débrided tissues yielded *M. aureus* (?), *B. capitovalis,* and *B. tetani.*

This patient was seen for the last time June 25, 1942. The wound had healed well and function of the thumb appeared to be good. She did not keep a later appointment and an attempt in August, 1944, to ascertain her subsequent history failed.

CASE 8.—J. C. (D. R. H.) a Negro man 35 years old, Aug. 2, 1942, in a fight received multiple lacerations, one 15 inches long, of the left thigh with partial severance of the vastus lateralis, tensor fasciae latae, and semimembranosus as well as several stab wounds in the neck, shoulder, and abdomen.

He was admitted to the hospital within the first hour and operated upon during the fifth hour after the injury was received.

A prophylactic dose of 1,500 units of tetanus antitoxin was given but no sulfonamide drugs were used. The wound was thoroughly washed with soapy water, completely débrided, and irrigated with large amounts of sterile physiologic saline solution. The layers were closed with silk, the skin with heavy catgut, under considerable tension.

The débrided tissues yielded *M. epidermidis,* a "hay bacillus," *Bacterium pyocyaneum,* and *B. tetani.*

Stitch abscesses developed in the major wound causing a separation of the skin and delaying healing but this infection was easily controlled by saline solution compresses and the wounds were all completely healed in twenty-three days. Cultures taken on the ninth day showed *Micrococcus aurantiacus, Micrococcus albus,* and *Str. viridans.*

He was last seen about one year later and had not developed tetanus.

CASE 9.—E. B. (D. R. H.), a Negro man 36 years old, in a fight on Sept. 7, 1942, in a beer hall, received a laceration twenty-three inches long extending almost from spine to sternum, along the upper left side of the chest wall level with the nipple, cutting through the latissimus dorsi and down to the scapula at one point. He was admitted to the hospital within the first hour, suffering from bronchitis and acute alcoholism, and was operated upon during the fourth hour after the injury was received. The wound was apparently not grossly contaminated and no serums or sulfonamides were used.

The wound was only lightly débrided, irrigated with physiologic saline solution, and closed in layers with silk sutures, not without some tension.

The débrided tissues yielded *Str. viridans, Streptococcus fecalis, M. epidermidis,* an unidentified species of anaerobic coccus, *B. sporogenes,* and *B. tetani.*

Owing perhaps to insufficient pressure on the dressing, a large hematoma developed in the dorsal end of the wound. Infection developed in this hematoma on the sixth day, with fever, swelling, and induration but no cultures were made at that time. In spite of this infection, the patient was well enough to be released from the hospital on the twelfth day. He returned to the clinic on the twenty-second day, at which time a culture showed *M. varians* and unidentified diphtheroids. Anaerobic cultures gave negative results. The wounds were all completely healed on the thirtieth day. He was last seen about two months later and had not developed tetanus.

CASE 10.—P. R. (D. R. H.), a Negro woman 43 years old, Nov. 20, 1942, was severely bitten by a dog on the left ankle and thigh, and also sustained a fracture of the left ring finger. She was admitted to the hospital within one hour, and operated upon during the third hour after the injury occurred. She received no antitoxin. The major bitten area was thoroughly washed with soapy water and completely excised, well irrigated with physiologic saline solution and covered with a split-thickness skin graft fastened with silk sutures; the minor puncture wounds were left open under petrolatum gauze dressings; 37 Gm. of sulfadiazine were administered orally during a period of ten days. Healing occurred without complications; the dressings were removed on the eighth day.

The débrided tissues yielded *Micrococcus citreus,* "hay bacilli," *B. perfringens,* and *B. tetani.*

She was last seen about one year later and had not developed tetanus.

BURNS

There were only 2 burns.

CASE 11.—F. P. (D. R.), a 73-year-old white man, slightly diabetic, on May 14, 1942, sustained second degree burns of the face and left elbow while trying to extinguish a fire in a barn. He was admitted to the hospital within one hour and operated upon during the second hour after the accident. The burned skin was washed with soapy water and was débrided. The arm was treated with Dymixal, a proprietary jelly containing crystal violet, brilliant green, and acriflavine. The face was treated with Dodecol, which contained 5 per cent sulfadizaine and 5 per cent sulfanilamide. These treatments were repeated daily for twelve days.

The débrided tissues yielded a nonhemolytic streptococcus, *M. varians, M. aureus, Micrococcus luteus, M. candidus, Corynebacterium sp.* (?), and *B. tetani.*

The burns on the face were healed by the fifteenth day; healing of the arm somewhat delayed by a slight infection but was complete by the twentieth day. The exact character of this infection was not determined.

He was still in good health after three months.

CASE 12.—R. J. (C. H.), a Negro man 24 years old, Aug. 3, 1942, sustained second and third degree burns of the lower legs and feet, first and second degree burns of the right arm and chest, lacerations of the face and hands, and a simple fracture of one arm during an

explosion of gasoline. He was admitted to the hospital within the first hour and operated upon during the sixth hour, having already received 3,000 units of tetanus antitoxin; he was also given two infusions of plasma, totaling 550 c.c. and four transfusions of whole blood, totaling 2,000 c.c.

No sulfonamide drugs were used up to this time. The burns were débrided and treated with saline pressure dressings. The fracture was reduced and splinted. Sulfadiazine, 41 Gm., were given orally during the first ten days.

The débrided tissues yielded *M. candidus, M. epidermidis,* "hay bacilli," *B. perfringens, B. bifermentans,* and *B. tertius.*

Upon changing the dressings on the left leg on the sixteenth day a gangrenous condition was discovered which required the amputation of that leg.

Cultures taken at that time yielded nonhemolytic streptococci, *M. aureus, M. albus, M. candidus, M. aurantiacus, M. epidermidis,* "diphtheroids," *B. bifermentans, B. tertius,* and *B. sporogenes* and several unidentified gram-negative rods.

On the twenty-third day a culture from the stump yielded all of these except *M. aurantiacus, M. albus, B. bifermentans,* and *B. tertius,* and in addition showed hemolytic streptococci to be present.

The patient was transferred to another hospital on the thirty-second day and three days later was reported to be suffering from tetanus. Sept. 5, 1944, he was reported as having recovered but details of his attack could not be obtained.

SUMMARY OF CASE HISTORIES

Summarizing these cases we note that there were 5 of compound fractures, 5 of lacerations, and 1 burn from débrided tissues of which *B. tetani* was recovered along with other bacteria of considerable variety. None of these developed tetanus.

In the case of one other burn, tetanus developed on the thirty-fifth day, three days after the patient's release from the hospital in which treatment was initiated. *B. tetani* was not recovered from the débrided tissues in this case.

DISCUSSION AND HISTORICAL SURVEY

There are two schools of thought with reference to the value of bacteriologic examinations of tissues surgically débrided from wounds. The first holds that cultures should always be made from such tissues in order to ascertain the potential infectors. As Pulaski, Meleney, and Spaeth[1] have pointed out, accidental wounds are always contaminated and no one can tell which wound is going to develop infection. "The knowledge of the bacterial flora in any given contaminated wound gives a sound basis for the rational prophylactic treatment to prevent infection in that wound."

The second school holds that cultures from débrided tissues can rarely yield any information of real practical value in time for the surgeon to utilize it, no matter how interesting it may be from an academic viewpoint. Those who belong to the second school believe that time and work involved are rarely justified unless, and until, clinical and microscopic evidence shows that infection has already started, in which case surgical decisions should be based primarily upon clinical and microscopic examinations which do not involve the loss of time required for the incubation of cultures. In these cases cultures may be made as a check upon the microscopic examination and to increase our knowledge, knowing that the findings can only rarely, if ever, influence surgical procedures except in a general way.

The very common occurrence of coagulase-positive staphylococcic infections, of hemolytic streptococci without streptococcal infections, of *B. perfringens* without gaseous gangrene, and the occasional occurrence of *B. histolyticus*[2] and other pathogens without specific infections illustrate this point of view.

On the other hand, the occurrence of *B. tetani* in wounds and the occasional delayed development of tetanus after primary healing when the passive immunity conferred by the routine administration of tetanus antitoxin has disappeared, suggest that it may be quite worth while to examine débrided tissues especially for this organism in order that suitable precautions may be taken, such as active immunization with tetanus toxoid or re-immunization with serum in the event of a new surgical emergency. There is a great difference in the cost of examining débrided tissues for *B. tetani* by such simple procedures as those outlined by Gilles[3, 4] and the complicated technique required for a complete aerobic and anaerobic examination.

CLINICAL CASES OF DELAYED TETANUS

The problem of delayed or idiopathic tetanus is quite old. According to Burnett,[5] Pescay, many years ago, observed a number of cases of generalized tetanus developing without obvious immediate causes in men who had marched the preceding day in a blazing sun in Spain, and Larey, in the Austrian campaign of 1809, attributed 110 cases of tetanus in a single day in wounded soldiers to the fact that the battle of Bautzen, in which they fought on an extremely hot day, was followed by a cold damp night. Sédillot also attributed an excessive incidence of tetanus after the battle of Constantine in 1836, to a similar situation.

In more recent times there have been many examples of men wounded in battle, apparently successfully treated prophylactically with tetanus antitoxin, by débridement, and by successful fixation of fractures, with complete or nearly complete healing, only to succumb to tetanus upon undue exertion, massage of old scars, exposure to sun, inoculation with quinine, or new surgical emergencies without the protection that might have been afforded by re-immunization with antitoxin or tetanus toxoid.

Courmont and Cordier,[6] in 1910, recorded two separate attacks of tetanus in the same subject, a gardener who developed general subacute tetanus following a puncture wound in the foot. This attack subsided after intensive treatment with tetanus antitoxin. Five years later the gardener fell, injuring his nose. This wound healed superficially but eleven days later tetanus again developed. This attack was also cured by antitoxin although not without a severe bout with serum-sickness.

Naturally, in this and other similar cases, the question arises whether the second attack was due to tetanus bacilli lying dormant in the old wound reactivated by the new injury or a totally new infection. The fact that the second attack in this case was of the cephalic type suggests the latter alternative.

Gubb and Duvernay,[7] in 1915, recorded a case, without any record of cultures, in which a period of seventy-seven days elapsed from injury until onset of symptoms, resulting fatally one week later.

Penhallow,[8] in 1916, recorded a case in a soldier precipitated by a new operation two months after receipt of his wound. This man recovered under intensive treatment with antitoxin.

Barling[9] had 3 patients with delayed tetanus under observation at one time. In one, tetanus occurred after fifty-one days, in another after fifty-three days, and in a third after forty days. All recovered from tetanus but the last died from a streptococcal gangrene which developed after seventy-three days.

Miller[10] had a patient who developed slight tetanus at seven days, from which the soldier apparently recovered but the attacks recurred on the seventy-

fourth day along with a bronchopneumonia, probably induced by chronic alcoholism, and ended fatally on the eighth day in spite of 9,000 units of tetanus antitoxin.

Doberer[11] recorded a case of delayed tetanus in a soldier 128 days after the wound was received, while Foster[12] had 3 cases of gunshot wounds, all promptly treated prophylactically with tetanus antitoxin, one occurring spontaneously at eighty-six days, one after a fall at 106 days, and the last after a fall followed by bronchopneumonia at 146 days.

Vernoni[13] reported 4 patients with tetanus with delayed or recurrent symptoms after intervals of fifty days in one, seventy days in two, and covering ten months in a fourth, precipitated by excessive exercise in 2 cases, massage of an old wound containing a foreign body in 1, and undue exposure to the sun in a fourth case. All eventually recovered.

Other cases of late tetanus were recorded in 1917 by Kaposi,[14] of recurrent tetanus by Westwater,[15] and of local tetanus as modified by the prophylactic use of tetanus antitoxin by Burrows.[16] However, in view of the record we can scarcely agree with Burrows that local tetanus is a new form of disease.

For long-term records we may cite a case by Brunzel[17] after six years. Brunzel's title says "*sieben Jahre*" but why exaggerate? The patient had been slightly wounded in the arm by a bursting grenade in 1915. The wound appeared at first to be healing but a little later an abscess developed from which a small piece of metal was removed. Moderate trismus and pain in the neck occurred at the time. No reference was made to cultures or use of antitoxin but the patient recovered, only to succumb to tetanus in 1921 in spite of intensive treatment with antitoxin.

Ernst,[18] in 1931, observed symptoms of tetanus six days after opening a small abscess in the scar of a wound fourteen years old. This patient recovered after heavy doses of antitoxin. There was no record of bacteriologic examinations. Bonney, Box, and MacLennan[19] recorded the case of a young unmarried woman who in 1928 underwent an operation for the removal of uterine fibroid tumors. Fifteen days later symptoms of tetanus developed but she recovered under treatment. *B. tetani* was not demonstrated in the discharges at that time. In 1938, ten years later, a new crop of fibroid tumors developed. She was given tetanus antitoxin and again operated upon. *B. tetani,* type III was recovered from the scar tissues. She recovered from the operation and did not develop tetanus again. Serum was negative for H and O agglutinins for her own culture and eight other antigenic types of *B. tetani.*

EXPERIMENTS ON DELAYED TETANUS

The experimental basis for our modern understanding of delayed tetanus was laid many years ago when Vaillard and Vincent[20] first showed, in 1891, that cultures of *B. tetani* grown at 20-22° C. were relatively nontoxic, that cultures grown at 37° C. and detoxified by heating at 65° C. for twenty minutes or by repeated washing could be injected into guinea pigs and rabbits without producing tetanus, that such organisms are phagocyted, both in vitro and in vivo, and that they may be reactivated by injections of lactic acid, trimethylamine, "*Microbacillus prodigiosus,*" and other bacteria, with the production of typical symptoms of tetanus ending in death. Although Sanchez-Toledo[21] was unable to confirm these observations which led to an amusing polemic with Vaillard,[22] the essential facts have been rechecked by many observers. It seems probable that Sanchez-Toledo actually had impure cultures although he claimed that they were pure; Vaillard and Rouget[23] also showed, in 1892, that repeated changes

are necessary to remove all toxin by washing and that excessive doses of either washed or heated cultures are likely to cause such experiments to fail.

Vincent,[24] in 1904, observed a case of so-called "idiopathic" or "spontaneous" tetanus in a man who took a walk in the sun on a hot day, in whom no site of infection could be determined. Following this, he was able to show that although frogs were insusceptible to tetanus at ordinary temperatures, they succumbed at 25 to 30° C. and that dogs, rabbits, and guinea pigs inoculated with detoxified spores of *B. tetani* succumbed to tetanus under the influence of insolation, exposure to temperatures of 38 to 42° C., or injections of quinine, in some cases after thirty, forty, or even sixty days. Often, *B. tetani* could be demonstrated at the site of inoculation of the quinine, indicating that the bacilli which had been phagocyted had not been killed and were probably transported by the mobile phagocytes to the site of the necrosis induced by the quinine. They were also found in the livers, spleens, bone marrows, and blood.

Tarrozi[25] showed that detoxified tetanus bacilli injected into rabbits could be reactivated by local injuries up to three and one-half months and could be recovered after death from the livers, spleens, kidneys, lungs, and bone marrows. Canfora[26] observed that during the first few days after subcutaneous or intravenous inoculation of rabbits with detoxified tetanus spores, the slightest wound would provoke an attack of tetanus and confirmed the presence of *B. tetani* in the livers, spleens, lungs, kidneys, and lymph glands, but the blood usually remained sterile.

Reinhardt and Assim[27] proved that these observations on animals were also applicable to man in 4 cases in which they recovered *B. tetani* from the livers, lungs, spleens, and in some instances from the kidneys, blood, and lymph glands.

The practical importance and relation of hypodermic injections of quinine to tetanus were studied by Semple,[28] Francis,[29] Browning,[30] Koser and McClelland,[31] and Teale and Bach[32] just prior to, during, and immediately after, World War I. What a fortunate thing it is in World War II, with fighting in the tropics causing the excessive exposure of our troops to heat and sun, the great hazard of malaria, and the consequent necessity of injections of quinine, that our soldiers have the protection afforded by active immunization with tetanus toxoid!

THE OCCURRENCE OF B. TETANI IN WOUNDS

With our modern understanding of the spreading habit of *B. tetani* upon solid media, in which *B. tetani* is as unique among the anaerobic bacteria as *Bact. proteus* is among the aerobes, we now consider that *B. tetani* is the easiest anaerobe to isolate in pur culture. Yet it has not always been so. When isolation was attempted from deep agar, pure cultures were particularly hard to secure. These difficulties were emphasized by Frothingham,[33] in 1894, and have been experienced by many investigators since then.

Probably the first instance in which *B. tetani* was recovered from a wound not resulting in tetanus was recorded by Bain,[34] in 1903. This was the case of a girl, 13 years old, who on July 3, 1902, sustained a wound in the hand from a blank cartridge. The wound was excised within fifty-five minutes at Massachusetts General Hospital in Boston. The child received no tetanus antitoxin but the wound healed promptly and she remained well. The debrided tissues, together with wadding and burnt powder grains, were sent to the bacteriologic laboratory where a culture of *B. tetani* was recovered from an unspecified mixture of organisms. Since no fermentation tests except milk were recorded,

we cannot be sure that this culture was pure but it was morphologically characteristic and produced tetanus in mice and guinea pigs. Bain emphasized that "this case should furnish a strong argument in favor of the early and complete incision of all wounds which from clinical experience are likely to be followed by tetanus."

Robertson,[35] studying the occurrence of *B. tetani* in war wounds, in 1917, made no attempt to isolate pure cultures, but organisms morphologically resembling *B. tetani* were found in 64 out of 252 wounds not developing tetanus. Of these, 60 cultures were tested on mice; only 9 produced tetanus. As a control upon these observations, specimens of pus from 45 cases of tetanus were studied. Eight of these failed to grow anaerobically, while of 37 showing anaerobic growth, only 29 showed organisms morphologically resembling *B. tetani*, and of 23 cultures tested for toxicity only 12 produced tetanus.

Weinberg and Séguin[36] in the same year recorded that in spite of prophylactic inoculations of all wounded men with tetanus antitoxin, *B. tetani* could be recovered from 9 per cent of them. As Sanford[37] said in 1918, "Tetanus is the black beast that lurks in the shadows for the convalescent wounded soldiers. The maelstrom of the battlefield may be safely passed; the soldier rejoices in having received only a slight shell wound, and is invalided home for a few weeks, but terrible indeed may be the end if that bit of shell has carried with it the spores of the anaerobic tetanus bacillus."

Harde[38] encountered *B. tetani* in two wounded men, neither of whom developed tetanus. Upon deciding to look for it routinely he found that he was unable to demonstrate it in 30 cases either by direct inoculation of mice or by microscopic examination and animal inoculations of mixed cultures. These methods failed in his hands even with frank cases of tetanus. The examination of 60 shell fragments extracted from wounds also gave negative results except in one instance.

It was Wilson and Steer,[39] who, in 1918, discovered that "*B. tetani* grows out from the main mass of the mixed growth as a very fine film with woolly margins," from which pure cultures could generally be picked on first trial. They recovered several pure cultures directly from wounds in this manner.

Adamson[40] also experienced great difficulty at first in demonstrating *B. tetani* in wounds and even failed in 9 instances of frank tetanus but later utilized the spreading characteristic successfully. Although Tulloch[41] did not emphasize this point he was probably quite familiar with it for he was able to demonstrate *B. tetani* in 21 out of 100 chronic wounds, as follows:

7 to 30 days	8 cases
32 to 64 days	5 cases
100 to 138 days	4 cases
305 days	1 case
733 to 882 days	3 cases

Finally, Fildes[42] exploited the spreading habit of *B. tetani* to isolate 75 new strains, among which were 6 strains from 6 cases of tetanus, following which we record a hiatus of fifteen years without further significant contributions in this field.

TETANUS IN WORLD WAR II

With the beginning of World War II the problem of tetanus rose again and in 1940, Rathcke[43] recorded the demonstration of *B. tetani* in 6 out of 140

wounds which he studied and emphasized again the necessity of using tetanus antitoxin routinely as a prophylactic in all wounded men.

But the conditions of this war are different from those of World War I in two important respects. First, most of the soldiers have been actively immunized with tetanus toxoid. Second, the local and systemic use of sulfonamide drugs has been widespread among wounded soldiers.

In France, where tetanus "anatoxin" or toxoid was first developed, almost all of the horses and soldiers were immunized and Firor[44] wrote, in 1942, that among 16,000 wounded men only one immunized man is known to have developed tetanus and he had a light case. Halford,[45] writing of the treacherous disaster at Pearl Harbor, recorded that almost all of the Naval and Military personnel who were wounded had already been immunized with tetanus toxoid and received a booster dose afterward. Although the normal incidence of tetanus in Hawaiians was about 5.7 per 100,000 annually, no tetanus developed in the Pearl Harbor group. Whether the copious use of sulfanilamide contributed to this remarkable fact is quite uncertain, but Welch, Slocum, and Herwich[46] showed experimentally that sulfanilamide introduced along with massive doses of tetanus spores into deep pockets of skin failed to prevent the development of tetanus sixty-five to seventy days later in 4 out of 20 guinea pigs. Interestingly enough, the 16 animals receiving smaller doses of spores and not developing tetanus failed to do so even when they were subjected to crushing injuries, or injected with cultures of staphylococcus or a mixture of kaolin and calcium chloride.

Boyd and MacLennan[47] recorded 5 cases of tetanus, 3 of them fatal, in soldiers immunized with two doses of toxoid, indicating that "the immunity afforded by inoculation with tetanus toxoid has its ceiling." One of the fatal cases had shown little or no immunologic response and these authors emphasized the value of three inoculations. The other two fatal cases were attributed to overwhelming infections resulting from inadequate débridement of the wounds, indicating the essential role of adequate surgery in the prophylaxis of tetanus. Norman[48] described a case of tetanus in a soldier who had received two doses of tetanus toxoid. Recovery occurred after the administration of 200,000 units of antitoxin. The use of three doses of toxoid is said now to be customary in the British Army.

In the United States Army, according to Long,[49] where the use of three inoculations of tetanus toxoid has been practiced since 1941, no cases of tetanus have been reported in immunized individuals, but it would be unsafe to predict that cases of delayed tetanus may not still appear among the wounded personnel.

Returning now to the problem of tetanus in civilian populations, we find a different situation because active immunization against tetanus in civilians has been practiced only to a very limited extent. Smith,[50] in 1942, recorded 7 cases of tetanus in a sector of London during the first two years of the war. All the patients were civilians except one, a soldier who had not been imunized. There was one case of delayed tetanus, three and one-half months after 3,000 units of antitoxin. Smith suggested that the question of immunizing the civilian population should be discussed, but so far as I know, the general immunization of civilians in London or any other city has not been undertaken.

SUMMARY

Eleven cases of civil wounds out of a total of 2,493 in which debrided tissues were studied yielded *B. tetani*. Five of these wounds involved compound fractures, 5 involved lacerations, and 1 was caused by a burn. Up to the present

time none of them has developed tetanus. One case of tetanus developed following a burn in which *B. tetani* was not recovered from the débrided tissues.

I believe that, generally speaking, the bacteriologic examination of tissues débrided from fresh wounds can rarely if ever yield any information in time to be of practical value to the surgeon, that surgical procedures in any given case must of necessity be based upon general knowledge and empirical considerations, that the very earliest intimation of infection should be followed at once by competent and judicious microscopic examinations upon which intelligent surgical procedures may be based, and that cultures should then be made for confirmation and extension of existing knowledge.

The occasional delayed development of tetanus suggests that if the examination of débrided tissues is ever justified the search should especially be directed to *B. tetani* in order that patients in whom this organism occurs may be either actively immunized with tetanus toxoid or passively immunized with antitoxin in the event of a new surgical emergency. But the real practical value of even this type of examination must be considered at the present time to rest largely upon theoretical considerations.

The problems of delayed or idiopathic tetanus, the occurrence of *B. tetani* in wounds, and tetanus in World War II are reviewed.

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GYNECOMASTIA

II. A Report of Five Additional Cases

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IN A recent publication[1] I discussed certain aspects of a type of male breast enlargement classed as gynecomastia. Seven cases were reported and discussed and several conclusions were drawn from study of this series. Among them are: (1) The enlarged breast causes discomfort; (2) other pathologic changes such as mastitis and neoplasm may be present, adding significance to the disease process and to the treatment; (3) prompt relief from symptoms and lasting cure are obtained through complete mastectomy which may be done satisfactorily through a transverse, infra-areolar incision.

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Five additional patients have been observed and treated. The results of study and treatment are in accord with those obtained from the first seven cases, and are offered now in supplement to the conclusions of the original series.

In all, twelve patients with gynecomastia have now been observed under similar circumstances. All complained of soreness or tenderness from pressure. In spite of the resemblance of the breast in gynecomastia to the pubertal female breast, the similarity apparently ends in its gross appearance. This is not simply an issue of masculine consciousness of an enlarged breast (though this point is not without significance), but it is also a matter of discomfort; the uniformity of complaint leaves no doubt that this disease is symptomatogenic. Most of these patients were referred for treatment with diagnoses such as neoplasm, adenoma, swelling of breast of unknown origin, hematoma, and, simply, soreness of breast.

TABLE I. SUMMARY OF FIVE ADDITIONAL CASES OF GYNECOMASTIA

CASE	AGE, RACE	DURATION	SIDE	TRAUMA	ENDOCRINE	DISCHARGE FROM NIPPLE	SYMPTOMS	PATHOLOGY REPORT
8	28 W	3 to 4 mo.	R	No	None	No	Soreness when running and exercising and from pressure	Gynecomastia
9	22 W	5 yr.	R	No	None	No	Soreness from pressure and from pack strap	Gynecomastia
10	28 W	1 yr.	RL	No	Mumps and orchitis in childhood; mild feminization	No	Soreness left breast from pressure and pack strap; no symptoms right breast	Gynecomastia, bilateral; left exhibits more epithelial hyperplasia of ducts than right
11	25 W	4 mo.	R	No	None	No	Increasing swelling, soreness, and pain; soreness from pack strap	Gynecomastia
12	19 W	1½ mo.	L	Bruise while wrestling 2 weeks before swelling	None	No	Steady growth; tenderness from pressure; breast irritated by pressure of clothes	Gynecomastia

Two cases in the present series deserve special comment. Patient 8 reported because of worry as much as because of discomfort. Four years previously his left breast had been excised, together with the nipple, because of a preoperative diagnosis of cancer. The size of the breast and the symptoms reported as having been present then were matched by those presented currently. A preoperative diagnosis of gynecomastia of the right breast was made, and the right breast was excised. The breast exhibited the typical gross and microscopic characteristics of this disease. It is not too surprising that a radical operation was done on the left breast for what was supposed to have been a benign condition, for those who have not seen many cases of gynecomastia, and who have not recognized the occasional case, may think first of malignancy. Fig. 1 illustrates the nonmutilating incision on the right side, as employed in this entire series; it is to be compared with the radical incision used to remove the left breast. This patient's happy subjective postoperative reaction is reiteration of the conclusion that complete excision of the breast, through the illustrated infra-areolar incision, yields a very satisfactory result.

Case 10 was interesting. The patient was a 28-year-old white soldier who had complained of soreness in the left breast for one year. He had been hospitalized once for twenty-one days and for seven days on another occasion, and

had been treated with hot packs at these times. Symptomatic improvement occurred during hospitalization. There was prompt relapse, however, and the soldier reported several additional times on sick call. Enlargement of both breasts was found on examination, although there was no complaint referable to the right breast. There probably was some endocrine disturbance, for there was a history of mumps and orchitis in early childhood. The testicles were small and there were stigmas of feminization, such as lack of hair on the chest, sparse hair on the face, and a female escutcheon. Additional evidence is offered by the fact of bilateral breast involvement, even though it did not occur until this comparatively late age. However, in other respects there was no deviation from the masculine pattern and the patient reported normal libido and satisfactory sexual activity. Although only the left breast was symptomatic, both breasts

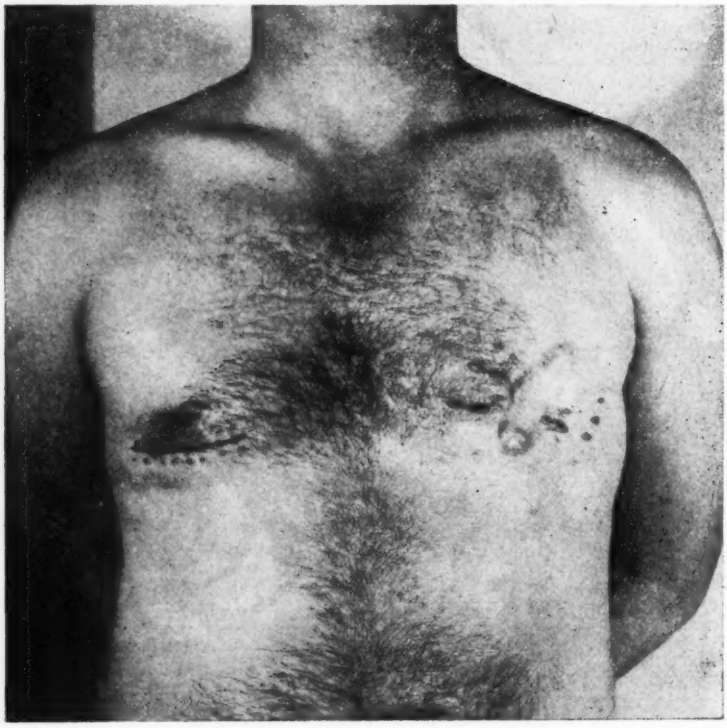

Fig. 1.—Patient 8 one month after right mastectomy; left mastectomy four years previously.

presented the histologic picture typical of gynecomastia. The left side, in addition, exhibited moderately edematous stroma and slight epithelial hyperplasia of the ducts. This patient was very grateful for the relief afforded him by mastectomy. He was so much improved that no doubt need exist that the several conservative measures employed in treating him during the previous year caused loss of time and created dissatisfaction.

CONCLUSIONS OF PRESENT SERIES OF FIVE CASES

1. Gynecomastia may be unilateral or bilateral. It is a disease of unknown origin which may be confused clinically with several other diseases of the breast.

2. Prompt relief of symptoms and permanent cure were obtained through complete mastectomy, as in the original series of seven cases.

3. The infra-areolar, transverse incision permitted complete excision of the breast, and is considered very satisfactory from the cosmetic viewpoint also.

4. The basic histologic picture in these five cases resembled that of the first seven cases: there were scattered ducts lying in poorly cellular collagenous connective tissue. The ducts were lined by one to three layers of columnar epithelium. Slight round-cell infiltration of the periductal stroma was seen in a few instances.

COMMENT ON THE SERIES OF TWELVE CASES

Although the enlarged breast of gynecomastia has been referred to as homologous with virginal hypertrophy of the female breast, no symptoms comparable to those presented by the soldier with gynecomastia are observed in the female whose breast is undergoing pubertal enlargement. Nor, if conclusions are to be drawn from this series, are pathologic changes of similar quality and frequency to be seen in the prepubertal or pubertal female breast. In this series, five breasts presented pathologic change of significance in addition to gynecomastia. This is out of proportion to the incidence of pathologic change in the female breast at any age, and particularly at the age in which the breast is at a stage of development similar to that of the breast of gynecomastia.

These superimposed features represented inflammation, irritation, and premalignancy. The finding of an intraductal papilloma with metaplasia is significant. Boyd states "there appears to be a definite relation between duct papilloma and duct carcinoma." It is to be doubted that conservative therapy of any type would suffice in such an instance or in instances such as those found in Cases 10 or 4,[1] where the relief by excision was dramatic after two years of discomfort. The high incidence of pathologic change in the breast of underlying gynecomastia and the universal symptomatology are, therefore, strong factors in distinguishing gynecomastia as a disease requiring specific treatment.

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A CASE REPORT OF BILATERAL ARTERIOVENOUS ANEURYSMS OF THE POSTERIOR TIBIAL ARTERIES

WITH AN INTERESTING OBSERVATION CONCERNING THE EFFECT OF VASODILATATION

MAJOR JOSEPH R. PLANK, MEDICAL CORPS, ARMY OF THE UNITED STATES

UP TO the present time, bilateral arteriovenous aneurysms occurring simultaneously in a patient have seldom, if ever, been reported. Aside from the rarity of the condition the management of such cases is no different than that of those cases in which only one arteriovenous aneurysm is present. However, it is well to re-emphasize that arteriovenous aneurysms are not infrequent in men receiving war injuries, especially certain types of injury. In general, grenades, mortars, and similar kinds of shells on exploding produce, literally speaking, showers of fragments both large and small, so that it is not infrequent for a soldier being in the close vicinity of such an exploding shell to have

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scores of small fragments penetrate the body. X-ray examinations of some such patients resemble those of patients who have received a concentrated load of buckshot, except that the fragments vary in size.

It is obviously both impossible and impractical in such cases to remove all the foreign bodies unless there is some specific reason for so doing, as for instance, infection or irritation to some structure in the region of the imbedded foreign body.

In those instances in which blood vessels are injured, it is quite often impossible to know definitely in the beginning whether or not the vessel has been injured unless a hematoma large enough to palpate develops suddenly or a pulsating hematoma appears. In other instances, segmental arterial spasm may develop, and, if a vessel of sufficient caliber is injured, this condition can be recognized clinically without having special diagnostic equipment, as an oscillometer, arteriography, or other special method or examination.

The time interval that may exist between the time of injury and the onset of the development of the arteriovenous aneurysm may vary widely between days and months or in some cases even longer. No definite rule can be made relative to the time elasping between the time of injury and the development of the fistula, nor to the size of the fistula. However, there are definite means by which one can and should evaluate the fistula or fistulas in each individual case and it is by employing the collected data in each case and evaluating properly that one can arrive at a correct method for handling the case.

The evaluation of the signs and symptoms of arteriovenous aneurysms has been enumerated and emphasized many times by R. Matas, Mont Reid, E. Holman, and many others. Reid and Andrews[1] devised the following outline for evaluating arteriovenous aneurysms and it takes into consideration all of the most important points.

1. Effect on the collateral circulation
2. Effect on the involved vessels
3. Effect on the heart
4. Effect on the blood pressure
5. Effect on the circulatory balance
6. Effect on the nutrition of the part beyond

In those cases in which the smaller distal arteries are involved as the anterior and posterior tibials and also the radial and ulnar arteries in which smaller fistulas are present, there will be no discernible clinical changes in the size of the heart, nor changes in the blood pressure or the pulse rate following occlusion of the fistula, and no effect on the circulatory balance. However, there may be changes in the nutrition of the part distal to the fistula. These changes may be very minimal and the most noteworthy sign may be only a greater prominence of the veins on the affected side than on the uninvolved side. There is one other symptom that these patients may complain of and that is intermittent changes of a functional nature in the nerve distal to the fistula and in the vicinity of the involved vessels; usually it is described as a hyperesthesia distal to the site of the fistula. The question may arise in such instances as to whether or not the nerve was injured at the time of the original injury. If such was the case, the signs of nerve injury would not be of such an intermittent character.

There are, as has been repeatedly emphasized by many investigators, two courses of action that one may follow in the management of such cases of small arteriovenous aneurysms. One is operative, and the other rest and observation.

In the instances in which it has been determined that only a very small distal fistula is present, there is certainly no harm in observing the patient for some time with the expectation that it may close spontaneously. However, the thrill that is present over the fistula and transmitted along the veins may be a source of worry and of annoyance to the patient. In such instances, and in those cases in which a compensation element is involved, it is probably much better to have surgery performed presently than to wait an indefinite period of time. Surgery should always be postponed until adequate collateral circulation is present. In those cases in which there are definite signs of impaired nutrition to the part distal to the fistula or in which systemic effects are present, there is no question but that surgery should be performed when adequate collateral circulation is present.

Gage[2, 3] has demonstrated and reported the effectiveness of sympathetic block as a preoperative measure in the surgical treatment of aneurysms of the peripheral arteries.

DeBakey[4, 5] has described one case of arteriovenous aneurysm between the internal carotid and cavernous sinus in which cervicodorsal sympathectomy produced a cessation of symptoms.

In this regard the effects of sympathetic interruption on the case of arteriovenous aneurysm to be reported here should be of interest. It is my opinion that besides the beneficial effects which this procedure produces on collateral circulation, it may be of some value in arteriovenous fistulas in determining the size of the fistula. Either spinal anesthesia or lumbar sympathetic ganglion block produces vasodilatation of the lower extremity vessels, and with the consequent decrease of peripheral resistance the thrill and bruit will disappear in those cases of small arteriovenous fistulas. In the case to be reported, this was repeated twice, as it was believed that the fistula may have closed spontaneously the first time. If the fistula is large enough it would obviously not disappear with removal of vasomotor tonus and, thus, decreasing of peripheral resistance. There may be some other explanation for the disappearance of the signs of the fistula than the one given.

CASE REPORT

A 24-year-old white infantry officer was wounded in action, March 19, 1944, at which time he sustained multiple soft tissue wounds to both legs due to mortar shell fragment. The wounds were surgically cleansed and a cast was applied to the left leg because of some loss of soft tissue over the gastrocnemius; there was also an injury to the left superficial peroneal nerve. He was admitted to this hospital April 14, 1944. One week after the patient entered the hospital, the cast was removed and the soft tissue wounds were all found healed. One week later it was found that there was a definite thrill present at about the level of the middle and lower third of the left posterior tibial artery. The murmur could be heard over the veins of the leg and thigh. Because of the similar multiple wounds over the right leg, it was examined very carefully and no fistula could be found. However, because of the suddenness of the development of the fistula of the left leg, the right leg was examined each day. On the sixth day after the development of the fistula of the left leg, definite signs of a fistula were found in the right leg. It was situated at the level of the middle and lower third of the right posterior tibial artery. Pressure dressings and bed rest were prescribed for the patient. At this point the patient encouraged his friends who could walk to feel his legs; the doctors were likewise interested. Even when both fistulas were occluded there was no change in his pulse rate. During the period of observation there were never any evidences of systemic effect nor of any changes in nutrition to the parts distal to the fistulas. Previous to the operation it was definitely determined by complete obliteration of the pulses in the region of the fistulas that there was adequate collateral circulation.

The arteriovenous fistula on the left side was operated upon May 24, 1944, and a fistula was found near the middle and upper third of the posterior tibial artery. Imbedded

in the muscle about 1 cm. from the fistula, a small metallic fragment was found. The fistula was about 5 mm. long and the lumen about 1 mm. in diameter, extending in an oblique direction between the artery and the vein. There was no evidence of injury to the nerve in this region. There was little scar tissue here and the fistula was ligated doubly, immediately adjacent to both the artery and the vein, with 000 silk and excised between the ligatures. It is recognized that there are other surgical procedures that in all cases, generally speaking, are superior to the method used in this case, as for example quadruple ligation and excision, yet it was felt that in this particular case the procedure employed was adequate. No evidence of recurrence developed.

The arteriovenous fistula on the right side was operated upon June 22, 1944. All signs of the fistula disappeared after the induction of the spinal anesthetic and in this instance the fistula could not be found. It was felt because the physical signs were much less pronounced on this side, that an extensive dissection to find it would not be justifiable in such a small fistula as was presumed to be present. At the time the patient was discharged from this hospital the thrill and continuous machinelike murmur were present.

CONCLUSIONS

1. A case of bilateral arteriovenous fistula of the right and left posterior tibial arteries is presented.

2. Attention is directed to their probable more frequent occurrence in patients sustaining multiple small wounds from mortar and grenade fragments than from those caused by larger missiles.

3. Attention is also directed to the possible value of determining the size, whether large or small, of a fistula in a terminal or distal vessel by instituting spinal anesthesia or lumbar sympathetic paravertebral shock, obliterating vasomotor tonus, and decreasing peripheral resistance.

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AN IMPROVED METHOD OF CIRCUMCISION

Use of Relaxation Incisions, Cotton Ligatures and Sutures

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(From The Station Hospital, Fort Sill, Oklahoma, Urologic Section of The Surgical Service)

ALTHOUGH circumcision has been performed since the days of antiquity and there are now a number of accepted methods, any improvement in technique should be worth while. I have performed more than 600 circumcisions at an Army station hospital during a four-year period (1941 to 1945). The patients were soldiers who had severe phimosis and its complications, such as acute and chronic balanoposthitis or condyloma acuminata. Various methods of circumcision which have been described in the literature have been tried. The procedure which is now followed at this hospital involves the use of relaxa-

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tion incisions, cotton ligatures, and cotton sutures. This technique has given uniformly more satisfactory results than the other procedures which were previously employed. Postoperative swelling, pain, and discomfort are diminished, and healing is hastened.

PROCEDURE

The following routine is employed. The patient is admitted to the urologic ward. He shaves the external genitalia and bathes, paying particular attention to cleansing of the genitals. If the prepuce cannot be retracted, the

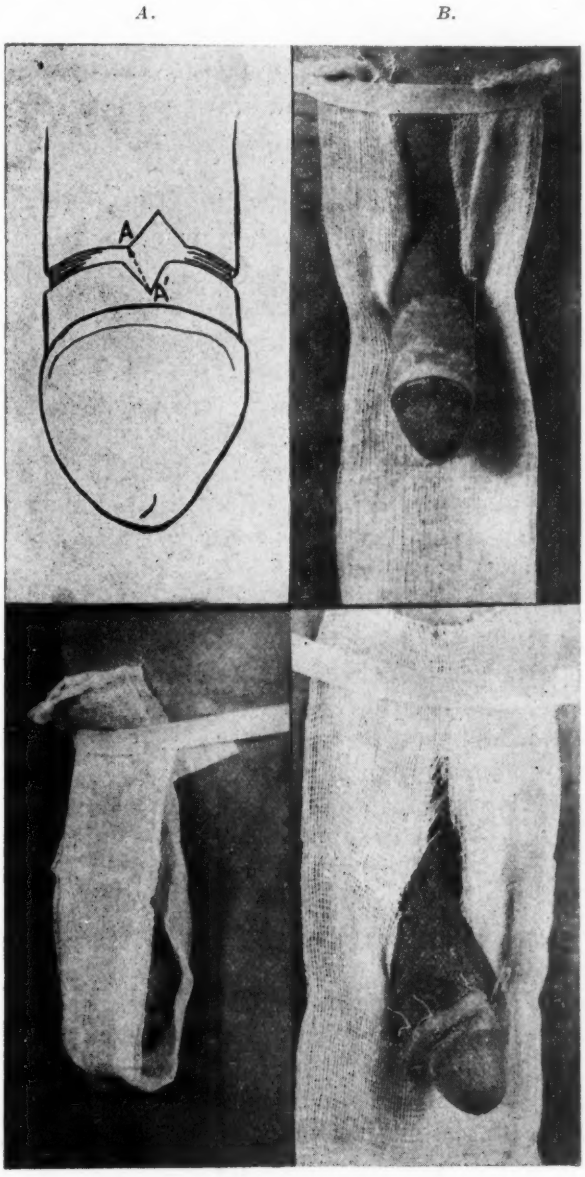

Fig. 1.—*A*, Showing V-shaped notches in cut edges of skin; when skin sutures are placed, *A* will be approximated to A^1. *B*, Sterile petrolatum gauze dressing has been applied, and the protective "gauze apron" is being placed in position. *C*, Dressing completed. *D*, Appearance on fourth postoperative day before removal of skin sutures.

preputial sac is irrigated with a 1:5,000 solution of potassium permanganate by the ward attendant. The patient is permitted to have a light breakfast, and is given sodium amytal, 0.194 Gm. (3 gr.), one hour prior to operation.

Tincture of merthiolate is used to prepare the operative field. A local anesthetic consisting of 1 per cent procaine solution is infiltrated around the base of the penis. The prepuce is retracted and any adhesions are freed. A second circular injection of the anesthetic is made into the inner leaf of the prepuce just behind the coronal sulcus; a minimal volume (2 to 3 c.c.) is used in order to avoid excessive ballooning and distortion of the tissues. In those cases in which the prepuce cannot be retracted, a dorsal slit is made after the line of incision is anesthetized and then the anesthetic is injected into the inner leaf of the prepuce as described. The tip of the prepuce is grasped with an Allis forceps on each side of the dorsal midline and another on the ventral midline. The dorsal slit is completed. Excessive prepuce is resected with curved scissors by cutting at right angles to the dorsal slit in line with the coronal margin. The latter incision is begun about one-fourth inch distal to the termination of the dorsal slit. The inner leaf of the prepuce is resected so that a collar remains which is about three-eighths of an inch in width. The dorsal slit has been intentionally elongated slightly beyond the origin of the circular incision. This results in a V-shaped notch in both wound edges, which will serve a valuable purpose.

All bleeding points are carefully clamped and ligated with No. 80 cotton. Careful attention to hemostasis is essential for good results. The cut edges are approximated, the two V-shaped notches being spread out in order to obtain increased laxity at the suture line and to prevent postoperative swelling, pain, and discomfort which otherwise occur. The notches are approximated as shown in Fig. 1*A*. A sufficient number of interrupted sutures of No. 40 cotton is used to approximate carefully the cut edges. A sterile petrolatum gauze dressing is applied (Fig. 1*B*), over which a protective "gauze apron" is placed (Fig. 1*C*).

An icecap is used for two days. Four cubic centimeters of elixir of triple bromides are given four times daily for three days in order to diminish erections. Analgesics are not required. The patient usually eats his first two meals in the ward, and thereafter he walks to the mess hall. The petrolatum gauze is removed on the second postoperative day, following which the wound is cleansed daily with hydrogen peroxide solution, and a fresh gauze apron is applied. The sutures are removed on the fourth day. By the fifth or sixth day the wound is usually well healed and the patient is discharged to full military duty.

DISCUSSION

In the past when catgut was used and before the relaxing incisions were employed, the wound edges usually became inflamed as a result of foreign body reaction. In addition, constriction at the suture line often occurred, resulting in swelling, pain, and discomfort. Since the new technique was instituted, the constriction has been eliminated by the use of the relaxing incisions. The wounds have been remarkably free of irritation, and the serous exudate which was so prominent with catgut has been negligible with the use of cotton. Furthermore, healing has occurred more rapidly, and patients are discharged one to two days earlier than formerly. This technique has been used in all of the last 200 cases.

In the military service, patients in operative cases are ordinarily hospitalized until they are ready for full military duty, therefore circumcised patients are kept on the ward. In civilian practice where patients are usually not kept in the hospital following circumcision, the use of this technique should cause less interference with the ability of the patient to carry out his usual activities while

the wound is healing. There is surprisingly little discomfort following operations in which the described technique is employed.

SUMMARY

1. A method of circumcision is described in which advantage is taken of a relaxation incision in the cut edges of the skin in order to produce increased laxity at the suture line.

2. The use of cotton ligatures and cotton sutures for circumcision is advocated.

3. The advantages of the described technique are twofold, namely (1) postoperative swelling, pain, and discomfort are diminished, and (2) healing occurs more rapidly.

Erratum

On page 20 of the July, 1945, issue of the JOURNAL, in the article "Explosions in Anesthesia" by Frank Cole, M.D., Minneapolis, Minn., in the ninth line from the bottom of the page, the word "neither" should be substituted for "either."

Book Reviews

An Outline of Tropical Medicine. By Otto Saphir, M.D. Chicago, 1944, The Michael Reese Research Foundation.

This small volume is the first publication by the Michael Reese Research Foundation for the Michael Reese Hospital of Chicago. In the introduction the author states, "This outline summarizes the barest essentials of the more important diseases encountered in the study of Tropical Medicine. It is neither a textbook nor a handbook. It is in no respect a complete treatise, but merely an outline in the strictest sense of the word. It perhaps can be described best as an extended vocabulary of Tropical Medicine." The reviewer agrees with this statement of the purpose of the volume. Significant tropical diseases are concisely described, particularly from the clinical point of view. References to more extended discussions of the diseases are appended to each chapter. The text is well indexed. For the average clinician, more comprehensive information will be necessary than is to be found in Saphir's book. It is difficult to ascertain for whom this outline has been prepared.

The Urinary Tract. A Handbook of Roentgen Diagnosis. By H. Dabney Kerr, M.D., and Carl L. Gillies, M.D., Chicago, 1944, The Year Book Publishers, Inc.

This small handbook is most compact and may well be the best book on the urinary tract from a roentgenologic standpoint. The material used in the preparation of the book has been obtained entirely from the records of the University Hospital of Iowa and the authors have examined and verified all the cases themselves. Consequently the book represents the experience and judgment of the authors and is not a review of the literature.

Practically every other page in the book is filled with reproductions of radiographs, the opposite page containing the description of the views. This makes for very easy reading of the text and ready reference to the roentgenogram being described. The authors did all the photographic work themselves, which probably accounts in part for the excellent reproductions. Because there are so many variations in abnormal as well as normal conditions, many examples of each condition are included.

The text begins with a brief discussion on preparation for urographic examinations in which the authors state that no routine preparation is used for most of their examinations.

The section on kidneys includes a good selection of normal pyelograms, chiefly retrograde studies, because the authors feel that anatomy can be better demonstrated by this method than by intravenous pyelograms. There is a fine discussion on pyelorenal backflow, congenital anomalies, and movable kidneys with excellent illustrations. Urinary stones are then discussed with illustrations of all the other calcifications which might be confusing. A relatively new entity known as calycine diverticulum is described and amply illustrated. This is followed by a long series of illustrations of all types of infections including formations of gas in urinary tract with infections. The final kidney section takes up tumors. At least one-third of the tumors show calcification. They feel retrograde studies are the best for the demonstration of tumors and also feel that distortion of the kidney outline is of prime importance.

The ureter is taken up in the second section of the book, which deals primarily with ureteral stones, but has good illustrations of anomalies, ureterectasis, and tuberculosis. There is no mention of ureteritis cystica and no illustrations of the deformity of the bladder occasionally seen around the ureteral orifice associated with a ureteral stone as it passes through the distal end of the ureter.

The third section of the book is concerned with the bladder. This is a very complete section with many excellent illustrations. Some unusual things are described and illustrated, such as an inguinal hernia containing the bladder, cystitis emphysematosa, tumor in a

diverticulum, and bladder tumors resulting from implants of kidney tumors. The authors also state that the bony deformities of the pelvis commonly associated with extrophy of the bladder may also be present with epispadius and bifurcation of the clitoris. They feel air cystograms are better for showing most bladder tumors and bladder stones which are very often uric acid stones.

The last section of the book takes up the urethra. It is a surprise to find that this is the second largest part of the book. The average radiologist and urologist places little emphasis on this part of the urinary tract from a roentgenographic standpoint. An excellent method of cysto-urethrography has been developed by Dr. Rubin H. Flocks, a urologist at the University of Iowa, and this is described in detail. Using this method the urologists apparently study a large percentage of their cases of prostatic hypertrophy. In the book the discussions and illustrations of prostate enlargement occupy more space than any other entity. The individual lobes of the prostate are visualized and it is possible to determine which lobes are enlarged. Many times carcinoma of the prostate produces a characteristic picture. This is also true of the neurogenic bladder. Most of this section is devoted to the posterior urethra, but there is also a short portion on the anterior urethra with a discussion of the differentiation of gonorrheal urethritis and strictures from traumatic strictures.

The book is enthusiastically recommended.

Operations of General Surgery. By Thomas G. Orr, M.D., Professor of Surgery, University of Kansas School of Medicine. Pp. 723. Kansas City, Kan., 1944. W. B. Saunders Company.

This text on the technique of operations of general surgery by one of America's well known surgeons is well done. Orr has succeeded in compressing into a single volume the technical procedures of a large broad field commonly referred to as general surgery—a province upon which the surgical specialists have made rather serious inroads. It is quite a feat in itself for a surgeon today who essays to do general surgery to write a text which embraces a good portion of all of operative surgery. There was a time, and not so long ago, that a single author text on operative surgery was not unusual. In more recent years, however, surgeons have concerned themselves more with attempts at achieving mastery in a single field rather than in many fields. In consequence, surgeons have found it necessary to acquaint themselves with a number of items relating to the field, which might be regarded as essentially non-surgical. This more ruminative attitude of the surgeon toward his work has improved the character of the surgery in fields where this practice is commonplace. Overspecialization, however, can lead to sterility just as certainly as studied efforts to achieve a uniform versatility in all fields. There is undoubtedly a middle ground for the surgeon in his work. The very breadth of surgery suggests, however, that this book by a distinguished American surgeon perhaps is one of the last of its line. In other words, the multiple-author technique of dealing with many subjects, in the main, has come to supplant the treatment of a large number of related subjects by a single author.

Structure and Function as Seen in the Foot. By Frederic Wood Jones, D.Sc., F.R.S., F.R.C.S. Baltimore, 1944, Williams & Wilkins Company. $7.50.

Wood Jones has given to us one of the most readable books on the anatomy of the foot that the reviewer has been privileged to peruse. He has discussed, both from the anatomic and from the anthropologic aspect, the importance of the foot to man's locomotor mechanism. The author's extremely interesting style of writing has made the review of this book very easy and thought provoking.

The statement that the distinct design of the foot separates man from all other forms of vertebrate life as much as any organ of the body, may give rise to much controversy of opinion. However, the reviewer feels that Wood Jones has presented enough evidence in his book to substantiate this remark.

The author emphasizes that the human foot has changed remarkably in its development from that of a grasping organ to that of a weight-bearing organ, while the human hand,

which always has been a grasping organ, has remained so but has been more highly developed. This is a concept that most anatomists have not presented before.

The author's discussion of muscle action is most interesting. In comparing the action of muscles in the forearm and in the foot, the author states that in the forearm the muscle origins, which are located proximally, serve as fixed points from which the movements of the digits in the hands are effected. However, in the lower extremity the tendinous insertions upon the distal bony segments serve as fixed points from which muscle action is enabled to control posture and movements of body weight.

Wood Jones has covered the make-up of the foot from the skin down to the bone and he has given a very comprehensive discussion on all the structures of the foot. The morphology of the foot is discussed at some length.

In conclusion, the author has not discussed the physiology of the foot function to any extent. With such a fine comprehensive review of the anatomy of the foot and its structures, a thorough discussion of the function and physiology of the foot would add to the interest of the book.

The volume is highly recommended to all men interested in the anatomy of the foot and especially to the orthopedist, as it will give him a new insight and concept of the function of the foot.

Shoulder Lesions. By H. F. Moseley, M.D., Springfield, Ill., 1945, Charles C Thomas.

This 180 page book is further evidence that the complex mechanism of the shoulder is gradually becoming better understood. Moseley shows that even this intricate member can be reduced to straightforward pathology and physiology. Each chapter is followed by a bibliography. Illustrations are graphic.

Twelve pages are devoted to functional anatomy. The Examination is discussed in four pages. A chapter on Rupture of the Rotator Cuff is most valuable. The identity of this group of injuries has been confused and misunderstood for too long. The other lesions, including bicipital syndromes, are also analyzed from the standpoint of pathology, diagnosis, and treatment. Francis L. McNaughton contributes the chapter on Neurological Aspects of Shoulder Pain. X-ray Diagnosis and Treatment is reviewed by Jean Bouchard and C. B. Peirce.

Indicative of the thoroughness with which the subject is handled are discussions of surgical approach and technique and of re-education programs for shoulder function. Twenty-two pages are given to case records. The subject is yet far from exhausted. Perhaps Moseley will see fit to add subsequent editions as new information comes to light. The book should be a part of every medical library.

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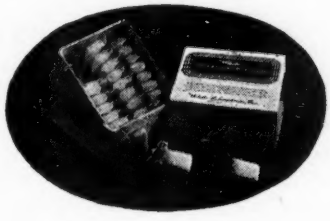

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